Using Bird Indices of Biotic Integrity to Assess the Condition of Wetlands in Montana

FINAL REPORT

Prepared for:

DEQ Contract #203100
Montana Department of Environmental Quality
U.S. Environmental Protection Agency

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Date Submitted: September 28, 2005

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Acknowledgments

This study was funded by a U.S. Environmental Protection Agency grant administered through the Montana Department of Environmental Quality. We especially want to thank Lynda Saul for all her support. We also want to thank the Montana Wetland Assessment and Monitoring Program working group members: Randy Apfelbeck, Marc Jones, and Bryce Maxell for their collaboration on this project, Kylan Frye and Megan Peterson for their tireless effort in the field, and the Avian Science Center staff for their advice and review of the methods and analysis.

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SUMMARY

This report documents the evaluation of birds as indicators of wetland condition, and the development of a bioassessment tool for headwater riparian areas in southwestern Montana based on songbird communities. As part of the Montana Department of Environmental Quality's Wetland and Assessment program, these biocriteria will be used to evaluate the condition of the state's wetlands.

Bird survey methods were tested and refined in 2003 and bird data collected in 2004 were used to develop a multimetric biological index (BIBI) for headwater streams in southwestern Montana. Results of the analysis were used to assess the role of habitat variation, including beaver activity, and make recommendations for improving the state's wetland sampling program to achieve more reliable assessments of bird communities along Montana streams. Implementation of an index of biological integrity will be useful in characterizing the existence and severity of wetland impairment, targeting and prioritizing sites and watersheds for protection and/or restoration, evaluating the effectiveness of restoration efforts, and evaluating the attainment of regional wetland protection goals.

I. Birds as Wetland Indicators

INTRODUCTION

Wetland and riparian areas in the arid western United States support a disproportionate diversity of aquatic and terrestrial wildlife, and are critical to the maintenance of the region's water resources (Knopf et al. 1988, Keddy 2000). Over the past century, land use activities such as mining, agriculture, urbanization, and industrialization have seriously threatened wetland and riparian areas throughout this region. An estimated 80% of riparian areas are severely degraded (U.S. Department of Interior 1994). In Montana, over 25% of wetlands have been lost, and the condition of those remaining is unknown (Dahl 1990). Wetland assessments are needed to evaluate the status and trends of wetland loss and conditions, and inform implementation of wetland restoration and protection decisions by managers. A key component of a wetland assessment program is a set of measurable indicators that can be used to consistently and efficiently assess wetland function (Karr 1991, U.S. EPA 2002).

The purpose of this study was to evaluate the potential for using bird assemblages as one of a suite of indicators of wetland condition in Montana. We followed the multimetric index of biotic integrity approach used by the U.S. Environmental Protection Agency and many states for bioassessments (Ohio 1987, Tetra Tech 2000, U.S. EPA 2002, Klemm et al 2003), where multiple measures of a biotic community are aggregated into a single index. Species and related groups of species respond to different aspects of an ecosystem. Therefore, a combination of metrics provides a more consistent response to a broad range of human impacts and can be used to rank overall condition of an ecosystem (Karr and Chu 1997, U.S. EPA 2002).

Indices of biotic integrity have been developed for numerous aquatic assemblages (Karr 1981, 1991, Klemm et al 2003), but the method has also shown promise in terrestrial taxa including birds (Bradford et al 1998, Canterbury et al 2000, Bryce et al 2002). Terrestrial indicators may be an important compliment to aquatic assessments because they respond directly to disturbances that often precede changes in the aquatic and physical characteristics of a wetland, such as impacts on riparian vegetation and in the surrounding watershed (Gregory et al 1991, Bryce 2002). Bird communities have been proposed as good indicators of ecosystem health (Block et al 1984, Morrison 1986, Croonquist and Brooks 1991) because they reflect an integration of a broad array of ecological conditions, including water quality, productivity, vegetation structure and composition, and landscape integrity (Adamus et al. 2001). Furthermore, a large number of bird species can be surveyed using one or more cost-effective techniques in a relatively small area, permitting the development of sensitive community-level indices (Hutto 1998).

This study was funded by the U.S. Environmental Protection Agency through the Montana Department of Environmental Quality's (DEQ) Wetland Monitoring and Assessment Program to develop biological indicators and field methods for wetlands in Montana. Surveys of vegetation, amphibians, and physical habitat, as well as qualitative rapid assessments of overall

condition were also conducted as part of the program. The objectives of our study were to: 1) evaluate birds as an assessment tool for riparian and depressional wetland types in two ecoregions, and 2) develop multimetric bird index of biological integrity (BIBI) for the wetland types where birds were determined an effective assessment tool.

METHODS

STUDY AREAS

Biological communities naturally vary across wetlands, reflecting climate, hydroperiod, habitat, and geomorphology. Partitioning this natural variability into relatively homogenous classes can aid in establishing reference conditions and establishing the role of human disturbance. The Montana DEQ is using a tiered approach, first grouping wetlands by ecoregion, then sub-basin, and finally by hydrogeomorphic (HGM) classes. Two sub-basins were selected for this study: the Middle Milk (4^{th}-level U.S. Geological Survey hydrologic unit code 10050004), and the Red Rock (4^{th}-level U.S. Geological Survey hydrologic unit code 10020001) representing the Northern Glaciated Plains and Montana Rocky Mountains ecoregions, respectively (Fig. 1.1).

The Middle Milk sub-basin, in north-central Montana, consists of glaciated plains and potholes dominated by short-grass prairie. The region's climate is semi-arid with mean temperatures ranging from 3.6º F to 84.9º F in Havre (Western Regional Climate Center 2004). Mean annual precipitation is 11.2 in with extreme year to year variability. Human activities in the region include agricultural conversion, livestock grazing, roads, and hydrologic modification for irrigation.

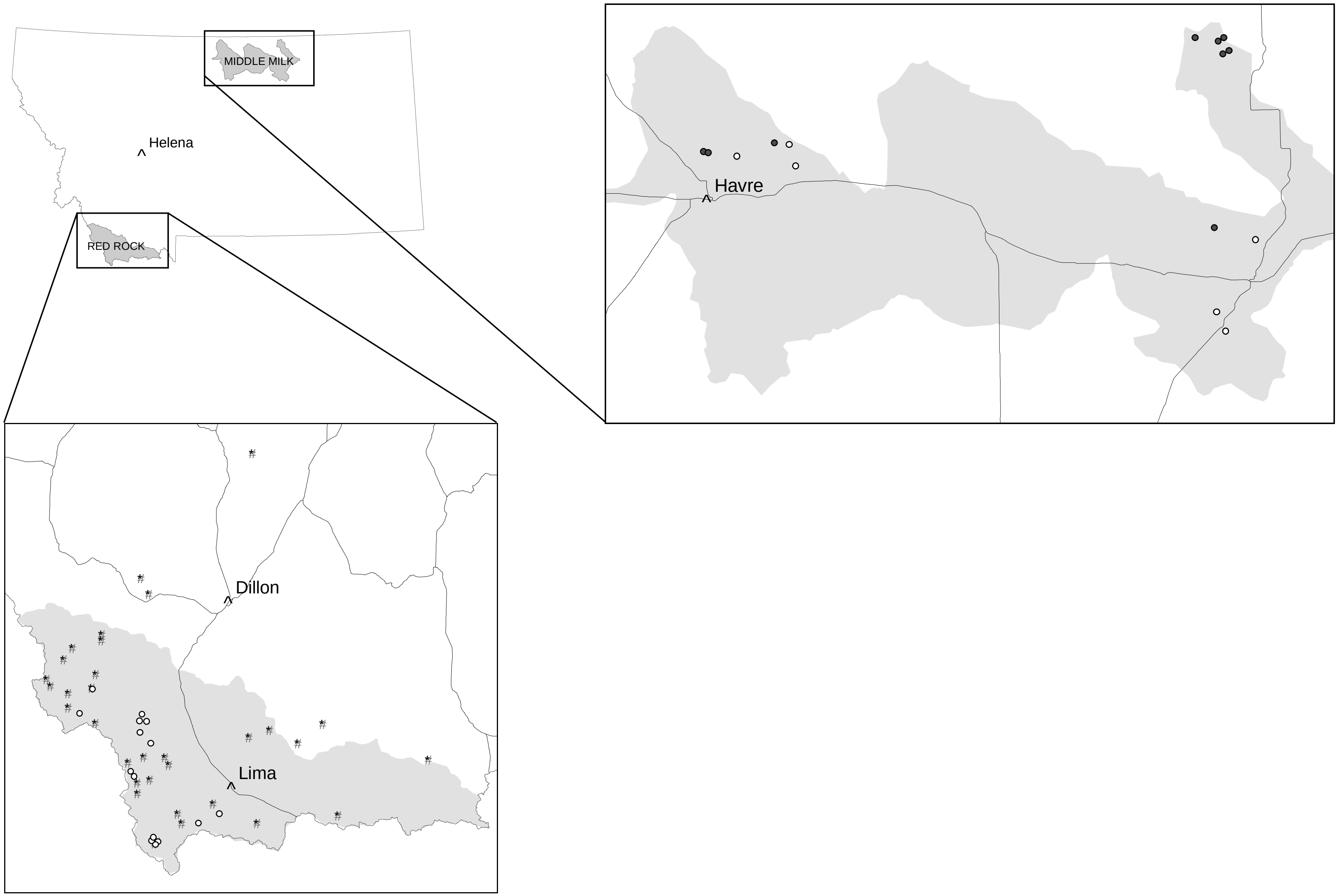
The Red Rocks sub-basin, in southwestern Montana, is characterized by high elevation forests and intermontane valleys of sagebrush and grassland, with numerous mountain-fed perennial streams (CEC 1997). The climate is cool and semi-arid, with mean temperatures at Dillon ranging from 20.8º F in January to 65.8º F in July, and mean annual precipitation of 9.7 in (Western Regional Climate Center 2004). Primary human disturbances in the area include livestock grazing, and hydrologic modification (dewatering) for irrigation of pasture.

SITE SELECTION

Middle Milk

We surveyed two wetland types, depressional and riparian, in the Middle Milk sub-basin. We sampled sites already used for developing a vegetation index of wetland condition for the DEQ Wetland Assessment Monitoring Program (Jones 2004). Depressional wetlands were restricted to temporarily and seasonally flooded palustrine emergent wetlands as defined by Cowardin et al. (1979) and mapped in the National Wetland Inventory (NWI). Intermittent and ephemeral riparian areas with a gradient from 0-2.0% were selected from the 1999 National Hydrography Dataset. Wetlands were sampled using a stratified random design. The 24 5^{th}-level watersheds within the Middle Milk sub-basin were ranked using landscape-scale surrogates of human disturbance, and the 3 least impacted, 3 moderately impacted, and the 3 most impacted watersheds were selected. Individual sampling sites were than randomly chosen within each

Figure 1.1. Locations of Middle Milk and Red Rocks study areas, and sites surveyed in 2003 and 2004.



selected watershed. Because this sampling strategy did not adequately represent the full range of wetland condition in the region, additional wetlands were selected based on consultation with federal and state resource agency personnel and local experts in the area (see Jones 2004).

Red Rocks

We surveyed riparian areas along headwater streams in the Red Rocks sub-basin. To ensure a range in condition, sites were selected from existing databases of steam quality acquired from the Bureau of Land Management (BLM) and U.S. Forest Service (USFS). BLM assessed stream reaches using the proper functioning condition (PFC) methodology, which is a qualitative evaluation of hydrology, vegetation, and erosion (Prichard et al. 1998). USFS uses quantitative hydro-geomorphological measures to assess the degree of departure from reference condition. The assessment methods differed slightly, but in each case sites were assigned to 3 condition classes: functioning/proper functioning condition (PFC), functioning at risk (FAR), or non-functioning (NF). Several sites outside the sub-basin were included to adequately sample within each condition class. Selection was limited to first- and second-order streams with < 2 percent slope and the potential to support a willow-riparian community.

DATA COLLECTION

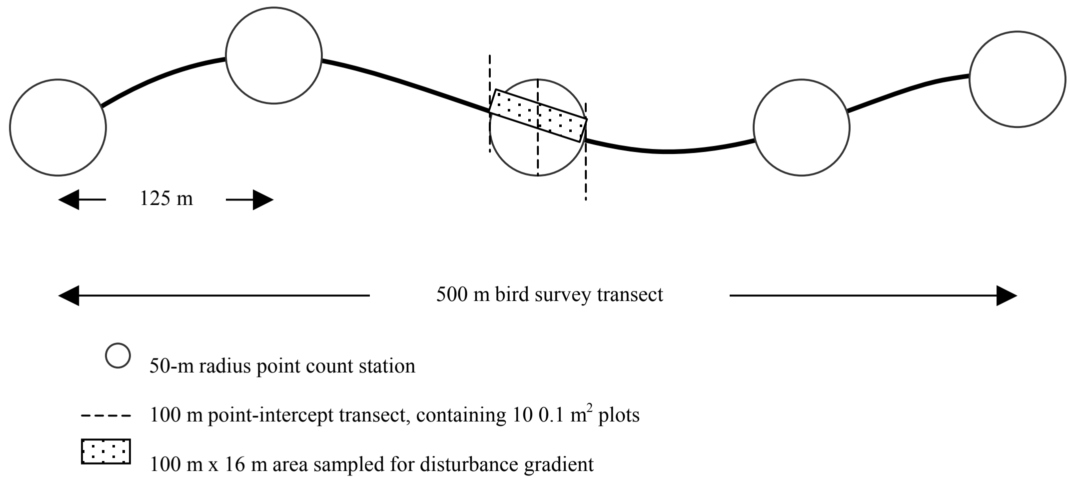
Bird Sampling

In 2003, we tested and refined two bird survey methods. Point counts, a standard bird survey technique where all birds detected by sight or sound are counted within a set time interval and distance from a single point (Ralph et al. 1995), were determined to be the best method for estimating songbird abundance, particularly in dense riparian vegetation. Area searches, involving a direct count of all birds detected while moving through a measured area over a given time (Slater 1994, Weller 1999), performed well for non-singing birds like waterfowl and shorebirds and songbird occurrence in areas where visibility was unobstructed, such as depressional wetlands.

Surveys were conducted in the four hours after dawn, on days with minimal precipitation and wind <15 mph. Since all of the depressional wetlands surveyed were <1 ha in size, we conducted an area search of the entire wetland, followed by a single unlimited radius 10-minute point count survey located in the wetland center. We sampled birds at riparian area sites along a 500-m transect located within 15 m of the stream edge (Fig. 1.2). Based on our findings in 2003, finalized riparian methods used in 2004 entailed 5-min point count surveys at 5 point count stations located every 125 m along the transect (Appendix C). All birds detected by sight or sound within 50-m of the point count station were recorded. Area searches for waterbirds were conducted along the transect between point counts. All sites were surveyed 2 times during the 2004 breeding season.

Both wetland types in the Middle Milk sub-basin were dropped from the study, based on site evaluations in the field and analysis of the bird data in 2003 (see Results section below. Therefore, they were not surveyed in 2004, and were not used for BIBI development.

Figure 1.2. Diagram of bird and vegetation sampling scheme for riparian sites in 2004.



Disturbance Gradient
We used the disturbance gradient developed for the DEQ Wetland Assessment and Monitoring Program for headwater riparian sites in Red Rocks by W.M. Jones (2005). Since the primary stressor of headwater streams in the Red Rocks sub-basin is livestock grazing and ungulate browse, measures were chosen that reliably responded to these impacts. A composite disturbance measure was developed using principal components analysis (PCA) of 4 variables: animal unit months (AUMs), amount of bare ground, bank stability, and browse intensity. AUMs were measured as the annual number and duration of cow-calf pairs within the allotment. The sample unit for all other variables was a 100-m reach centered within the 500-m bird survey transect. The reach was sub-sampled along transects running parallel and perpendicular to the stream, such than an area of 100 m x 16 m was sampled (Fig. 1.2). The first principle component, which explained 58.8% of the variation, was rescaled from least disturbed scored as 0 and most disturbed scored as 1.

Vegetation Sampling
Vegetation was sampled only at sites visited in 2004 in the Red Rocks sub-basin. For comparability, we measured vegetation using the same sampling unit as the human disturbance gradient (100-m reach located in the center of the bird survey transect). We sampled tree density by species and size class and estimated tree canopy height within a 50-m radius plot located at the middle point count station of the bird survey transect. Shrub and ground cover were measured along three 100 m transects placed perpendicular to the stream (Fig. 1.2). Transects were 50 m apart, with the center vegetation transect crossing the bird survey transect at the middle point count station. Shrub cover was sampled using the point intercept method every 2 m along each transect (Mueller-Dombois and Ellenberg 1974, Elzinga et al.1998). From these data we calculated the percent cover of shrubs by species in 4 height classes (<1 m, 1-2 m, 2-3 m, and >3 m). We also measured the proportion of shrubs with >50% live stems. Ground cover was

estimated within 0.1 m^2 quadrats located at 10 m intervals along each transect. Ground cover was classified as grass, forb, sedge, rush, bare, rock, water, and other. Width of the riparian zone was sampled at the same location as each vegetation transect, and was measured from the outermost band of riparian vegetation on either side of the stream.

Rapid Assessment

We used rapid assessment results for headwater riparian sites surveyed by the Montana DEQ in 2004. The Montana DEQ wetland rapid assessment ranks wetland sites by scoring a range of site conditions, including water quality, hydrogeomorphology, buffer (adjacent upland land use), and vegetation, and combining them into an overall condition score (Montana DEQ 2004). For riparian areas, the sample unit was a 100-m stretch of stream.

MULTIMETRIC ANALYSIS

Candidate Metrics

We derived candidate bird metrics from mean bird species occurrence and relative abundance data collected using finalized bird survey methods in 2004. We used the maximum abundance from the two survey days, and considered a species present if it was detected at a site on at least one survey date.

We considered bird metrics that have been shown to be responsive to livestock grazing or other human disturbances (Croonquist and Brooks 1991, Saab et al 1995, Bradford et al. 1998, Bryce et al. 2002), and for which we had sufficient representation in our data set. The 41 metrics considered represented different aspects of community composition, diet, nesting, and foraging guilds, and individual species (Table 1.1). For most metrics, we evaluated more than one measure of the bird attribute, including the number of individuals, the number of species, and/or the presence of species.

Community Composition

We considered the total number of species, or species richness, and two measures of diversity based on the abundance and evenness of species present. We used the Shannon index of diversity (*H')*, which is calculated as:

$$H' = -\sum_{i=1} p_i \ln p_i$$

and Simpson's Diversity (D):

$$D = 1 \Big/ \sum_{i=1} p_i^{\,2}$$

where p_i is the proportion of individuals found in the ith species.

Table 1.1. Candidate metrics, measure considered, and expected response to disturbance.

Metric Categories	Expected Response	Measures[a]
Community Composition:		
Species richness	Decrease	2
Shannon's diversity index (*H*)	Decrease	n/a
Simpson's diversity (D)	Decrease	n/a
Neotropical migrants	Decrease	1,2
Riparian dependent/obligates	Decrease	1,2
Warblers	Decrease	1,2
Dietary Preference:		
Insectivores	Increase	1,2
Granivores	Increase	1,2
Omnivores	Decrease	1,2
Foraging Strategy:		
Aerial foragers	Decrease	1,2
Ground gleaners	Increase	1,2
Foliage gleaners	Decrease	1,2
Nest Location:		
Ground	Decrease	1,2
Shrub	Decrease	1,2
Tree	Decrease	1,2
Cavity	Decrease	1,2
Individual Species:		
Lincoln's Sparrow	Decrease	1,3
Song Sparrow	Decrease	1,3
Warbling Vireo	Decrease	1,3
Yellow warbler	Decrease	1,3
Brown headed cowbird	Increase	3
Gray Catbird	Decrease	3
House Wren	Decrease	3
Lazuli Bunting	Decrease	3

[a]For each metric (except Shannon's diversity) the number of individuals, the number of species, and/or the presence of species were considered (labeled 1, 2, and3, respectively).

We also examined species groups known to be declining due to human disturbance, including the richness and abundance of warblers, neotropical migrants, and riparian dependent or obligate species (Wilcove and Terborgh 1984, Bock et al 1993, DeSante and George 1994). Species were considered riparian dependents when 60-90% of their abundance occurs in riparian vegetation during the breeding season. Obligates were defined as species with >90% of their abundance in riparian vegetation during the same period (BLM no date).

Diet, Nesting, and Foraging Guilds

Response guilds, which are groups of species that require similar habitat, food, or other elements for survival, are considered good indicators of disturbance (Mannan et al 1984, Szaro 1986, Croonquist and Brooks 1991). Species were assigned to guilds based on diet, nest location, and foraging strategy as indicated in Ehrlich et al.(1988). Dietary preference metrics considered included insectivores, granivores, and omnivores. Within this group, insectivores were expected to be the most sensitive to grazing impacts (Krueper et al. 2003).

Metrics based on foraging strategy included aerial foragers, ground gleaners, and foliage gleaners. We also considered native ground, shrub, tree, and cavity nesting species. Predation on shrub and ground nesting birds is typically higher in areas with more roads and trails and greater habitat fragmentation (Vander Haegen and Degraaf 1996), and ground nesting birds have been found to be particularly sensitive to livestock grazing (Saab et al. 1995, Ammon and Stacey 1997). Cavity nesting birds are negatively influenced by overgrazing and landscape-scale changes that decrease the availability of nesting sites and increase the number of exotic European starlings, an aggressive competitor for limited cavity sites (Dobkin et al 1995).

Individual Species

We considered individual species that are associated with riparian habitats for which we had sufficient data. We developed metrics based on 8 dependent and obligate riparian species that were detected in at least 25% of the survey sites in 2004: Lincoln's Sparrow, Song Sparrow, Warbling Vireo, Yellow Warbler, Brown-headed Cowbird, Gray Catbird, House Wren, and Lazuli Bunting.

Metric Selection

We evaluated candidate metrics based on their responsiveness to human disturbance, ability to discriminate among sites, and metric redundancy (U.S. EPA 2002). We looked for relationships between candidate metrics and the disturbance gradient by examining Spearman rank correlation coefficients (r_s) and scatterplots. Metrics with $r_s > 0.5$ or a strong curvilinear relationship were retained. We assessed the discriminatory power of each metric by comparing the least and most impaired sites through graphical assessment using box plots (Tetra Tech 2000, Jones 2005). We considered least impaired sites those with a disturbance gradient score <25th percentile (0.29), and most impaired sites as those with a score $r_s >$ the 75th percentile (0.72). Only metrics with no overlap of the interquartile range (middle 50% of observations), and no overlap of median and interquartile range were retained for further evaluation. Finally, we evaluated the remaining metrics for redundancy. When two or more metrics had an $r_s > 0.9$, the one with the greatest discriminatory power and responsiveness to disturbance was retained (U.S. EPA 1998).

Metric Scoring

Metrics were standardized to a continuous scale from 0 to 100, so that all metrics describe increasing site conditions as scores increase toward 100, and are equally weighted when combined into a single index. We followed the methodology used by Tetra Tech (2000) because it was found to perform well compared to other discrete and continuous scoring methods (Blockstrom 2003). To reduce the effect of outlier values on the final index, the upper threshold for each metric was set at the 95th percentile (5th percentile for metrics that increased in value with increasing site disturbance) by assigning a score of 100 to metric values ≥ the 95th percentile (5th

percentile) for all sites. For metrics that decreased in response to disturbance, metrics were scored proportionally using the equation:

$$\text{Score} = \left(\frac{\text{metric score}}{\text{95th percentile}}\right)\times 100$$

For metrics that increased with disturbance, we used the following equation:

$$\text{Score} = \left(\frac{\text{100 - metric score}}{\text{100 - 5th percentile}}\right)\times 100$$

BIBI Development and Evaluation

Once all metrics were converted to the 100 point scale, they were combined into a single multimetric BIBI index by averaging the individual metrics for the site (Tetra Tech 2000). Linear regression was used to evaluate the relationship between the BIBI and the disturbance gradient. We also used linear regression to compare the strength of the relationship between the BIBI the rapid assessment category scores. To evaluate potential confounding relationships between the disturbance gradient and natural variation in the sites, we examined the data for any correlations between disturbance and a suite of vegetation measures, including width of the riparian zone, tree species density, and the percent cover of each ground cover class (except bare ground). We did not consider correlation with measures of riparian shrub cover a confounding factor, since ungulate grazing and browse is known to influence shrub structure. We used SPSS software to perform all statistical analyses and to test assumptions associated with each test (SPSS 2003).

RESULTS

BIRD ASSEMBLAGES

Middle Milk

We conducted bird surveys at 11 riparian sites and 10 depressional sites in the Middle Milk study area from June 11 to July 13 2003 (Fig. 1.1). There were a total of 22 bird species detected at depressional wetland sites. During both point count and area search surveys, 133 and 171 individuals were counted, respectively. We detected 38 total species at riparian area sites with a total of 441 and 384 individuals were counted during point counts and area searches, respectively (Appendix A.1).

Temporarily and seasonally flooded depressional wetlands in the Middle Milk sub-basin were considered too dry in most years to support sufficient wetland-associated bird species to develop a wetland assessment tool using birds. Only one of the sites we visited in 2003 contained standing water, and <5 contained any area saturated soils. Furthermore, water rather than site condition appeared to be the most significant factor influencing the occurrence and abundance of wetland-associated bird species. In addition, many wetland bird species are known to have minimum wetland size requirements, and because most of the sites were <1ha, these sites are unlikely to be important areas for such species. Riparian areas in the region were dropped because the primary factor influencing bird species occurrence across sites was the amount of riparian shrub and tree cover, yet it is unclear how historical human disturbance and/or natural variation influences the presence of woody vegetation in these seasonal streams.

Red Rocks

In 2003, bird surveys were conducted at 17 headwater riparian sites in the Red Rocks study area from 30 May to 29 June (Fig. 1.1). Five of these sites were surveyed twice during the breeding season to examine the influence of seasonal variation. We detected 47 species, and 628 and 436 individuals during point counts and area searches, respectively (Appendix A.2).

In 2004 we used the finalized protocols developed for riparian sites to conduct 2 surveys at 33 headwater riparian sites during the breeding season from 24 May to 17 July (Fig. 1.1). We sampled 10 sites ranked as PFC, 15 as FAR, and 8 as NF. We detected a total of 63 bird species, and 1,720 individuals (Appendix A.3).

METRIC SELECTION AND BIBI PERFORMANCE

Of the 41 metrics evaluated, 5 were retained for inclusion in the final bird index: species richness of shrub nesters, and relative abundance of insectivores, warblers, Neotropical migrants, and riparian obligates/dependents (Fig.1.3). We eliminated 33 metrics because they had a weak relationship with the disturbance gradient, 2 were dropped due to poor discriminatory power, and 1 was removed based on redundancies among the remaining metrics. There was no correlation between the disturbance gradient and measures of natural variability among sites. One site, INDIAN, was excluded from the analyses because it was an extreme outlier due to the location of the disturbance gradient sampling plot within an exclosure that only included a small portion of the bird survey area. Individual metric scores and BIBI scores for each site are listed in Appendix B.1.

Table 1.2. Results for linear regression of BIBI and DEQ rapid assessment categories for 20 of sites visited in Red Rocks study area in 2004.

Rapid Assessment Category	$F_{1, 19}$	r^2	P
Water Quality	3.49	0.16	0.080
Hydrogeomorphology	2.57	0.12	0.125
Buffer	0.41	0.02	0.527
Vegetation	10.27	0.35	0.005
Overall Condition	6.80	0.26	0.017

Figure 1.3. Performance of 5 metrics selected based on scatterplots of relationship with disturbance (r_s = Spearman rank correlation coefficient) and box plots of least and most disturbed sites.

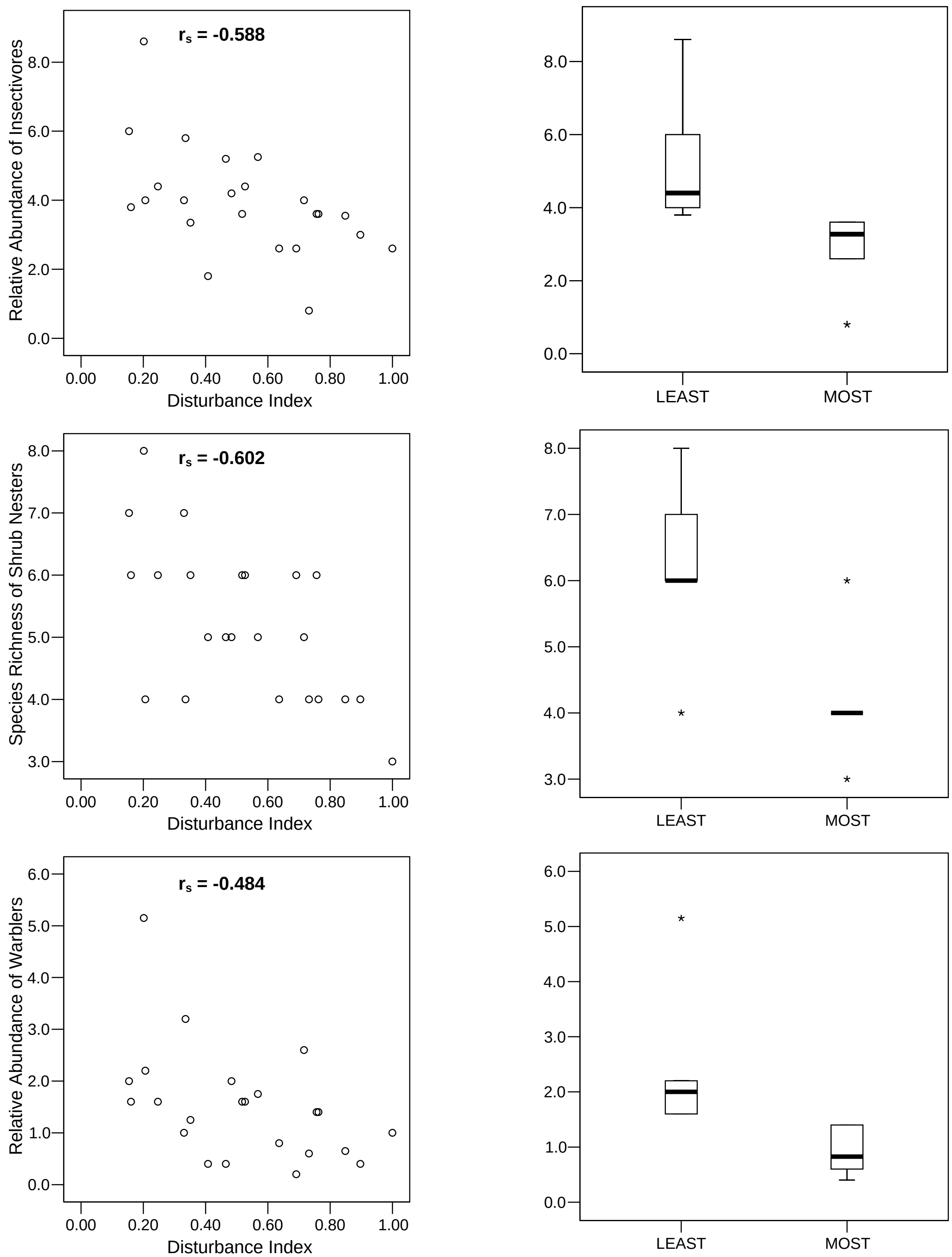
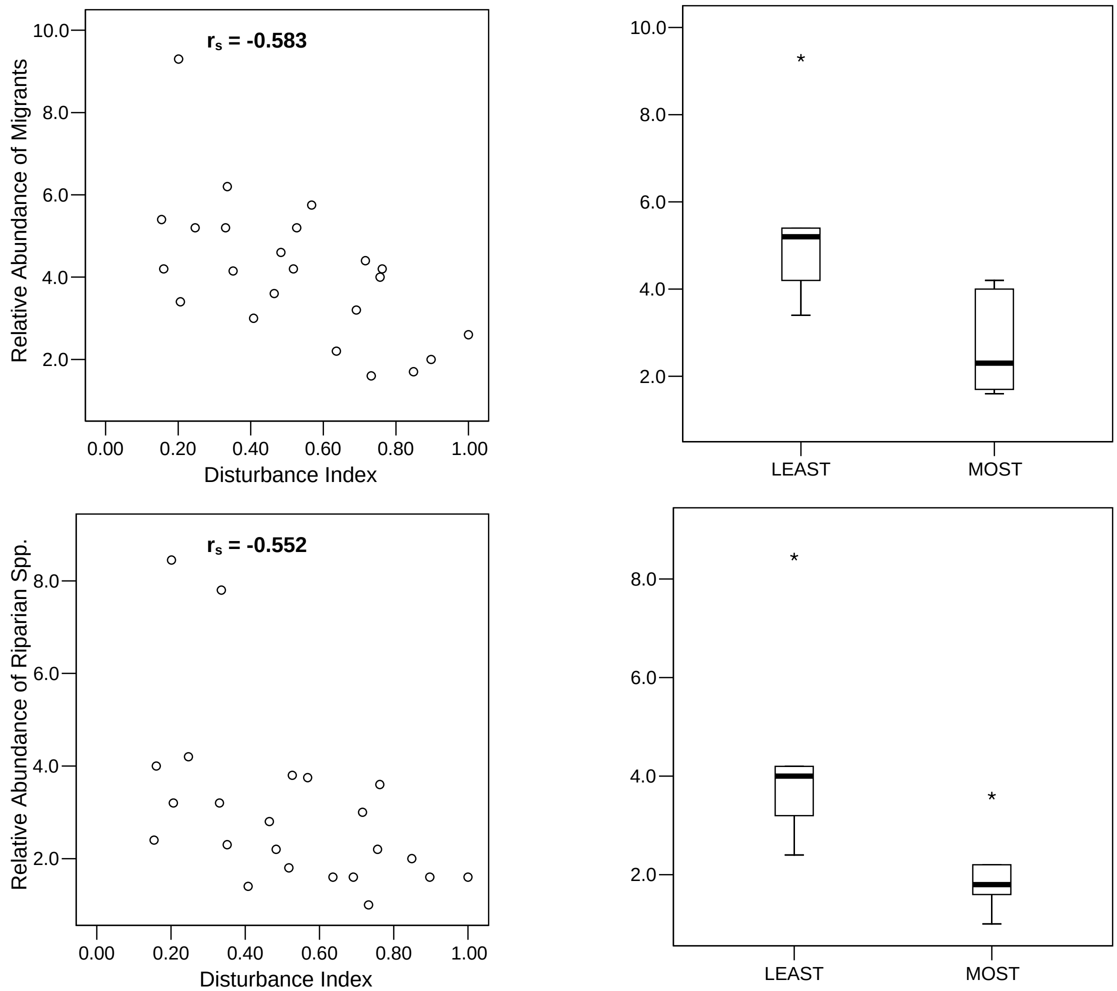


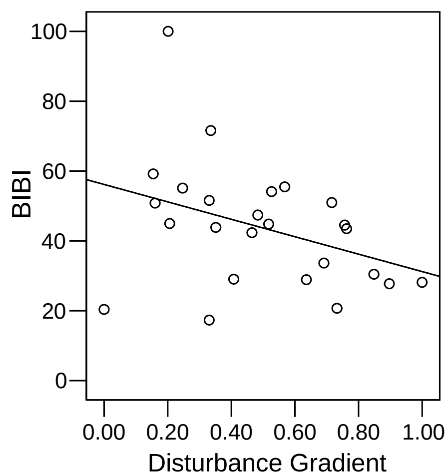
Figure 1.3 Continued. Performance of 5 metrics selected based on scatterplots of relationship with disturbance (r_s = Spearman rank correlation coefficient) and box plots of least and most disturbed sites.



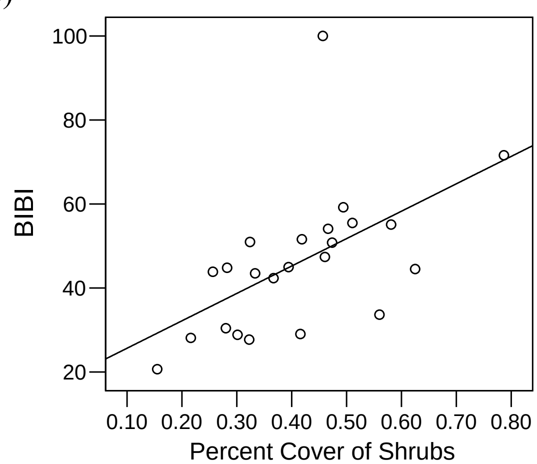
The final BIBI showed a significant linear relationship with the disturbance gradient (Fig. 1.4, BIBI = -42.7(disturbance) + 68.3, $F_{1, 21} = 13.72$, $r^2 = 0.40$, $P < 0.001$). Of the rapid assessment categories, the vegetation and overall condition scores were significantly ($P < 0.05$) related to the BIBI (Table 1.2). Since the BIBI was most strongly associated with the vegetation category, we further examined the individual attributes included in this category. Of these, shrub architecture, shrub health, and shrub density had the strongest correlations with the BIBI. Quantitative measures of two of these attributes, shrub health and shrub density, were sampled along the vegetation transects. Shrub health is the proportion of riparian shrubs with mostly dead stems (>50%) and shrub density is the percent cover of riparian shrubs >1 m tall. Each of these vegetation measures were related to the BIBI (Fig. 1.4; shrub health: $F_{1, 21} = 8.067$, $r^2 = 0.28$, $P = 0.010$, shrub density: $F_{1, 21} = 9.421$, $R^2 = 0.31$, $P = 0.006$).

Figure 1.4. Linear regression of BIBI and a) the disturbance gradient, b) shrub health, and c) shrub density for headwater riparian sites in the Red Rocks study area.

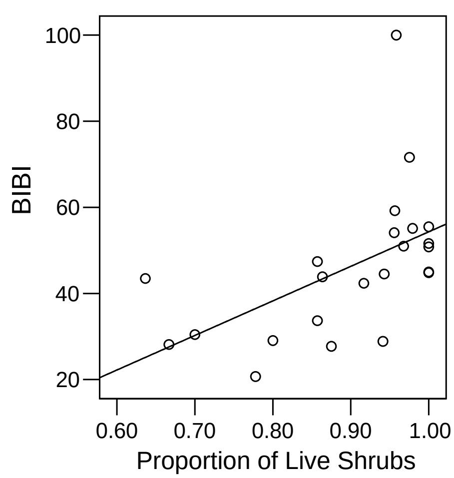
a)



c)



b)



DISCUSSION

Since wetland and riparian areas in the western United States support the highest number and diversity of bird species (Knopf et al 1988), the bird community constitutes an important aspect of the ecological functioning of these systems. Our findings suggest that a biotic index based on bird assemblages can be a useful tool for assessing the cumulative impacts of grazing in riparian areas along headwater streams in the Red Rocks sub-basin. However, we found that the bird community was not an effective indicator of condition in small, ephemeral streams and wetlands in the Middle Milk sub-basin. Similar to the findings of previous studies aimed at selecting bird community indicators of ecological condition, we found models based on species groups performed more robustly than individual species (Bradford et al 1998, Canterbury et al 2000, Bryce et al 2002). All of the species groups (Neotropical migrants, riparian species, and warblers) and two of the functional groups (insectivores and shrub nesters) were selected for inclusion in the final index. Indices made up of metrics based on species groups rather than individual species may be more efficient since survey data is pooled, potentially requiring fewer total detections and therefore smaller survey units. Species groups are also potentially more robust to regional variation in the bird community.

Although a relationship between the BIBI we developed and the disturbance gradient was found, much of the variation in bird community remained unexplained ($r^2 = 0.40$). This may limit the ability of the index to meaningfully discriminate among riparian site conditions. Much of this variation is likely attributable to the small sample size used in analysis. Of the 33 sites we surveyed in 2004, only 23 had an associated disturbance gradient score and 22 had a completed rapid assessment.

Another factor that likely influenced the apparent utility of the BIBI is the disturbance measures included in the disturbance gradient, and the scale at which they were sampled. With the exception of AUMs, the disturbance gradient was developed from measures within 8 m of the stream bank, yet birds utilize the entire riparian zone. Furthermore, disturbance measures were only sampled along 100m of the 500 m transect required to obtain an adequate sample of the bird community. Therefore, some discrepancy between disturbance estimates and actual disturbance at the scale of the bird surveys is expected. Also, the disturbance gradient primarily captured streamside grazing impacts associated with livestock trampling, such as bank stability and bare soil, while our analyses of the rapid assessment categories suggest that the BIBI is most strongly influenced by riparian shrub condition. These measures were not included in the disturbance gradient developed by Jones (2005) because he used the gradient to develop an IBI for vegetation, and therefore any vegetation measures included in the gradient would inherently be correlated.

It is important to develop assessment tools at the appropriate scale to capture the overall impacts of human activities, such as livestock grazing, across the entire wetland or riparian area (U.S. EPA 2002). Many assessment programs focus entirely on the condition of the aquatic system, while ignoring the terrestrial environment. However, the sources of impaired water quality are often outside the waterbody, and many of the restoration efforts to improve stream condition are applied through land-based management practices (Bryce et al 2002). One of the advantages of the BIBI as an assessment tool for riparian areas is its responsiveness to both streamside disturbance as captured in the disturbance gradient, water quality as measured in the rapid assessment, and vegetation condition within the entire riparian zone. Numerous studies have found riparian birds to be highly dependent on the complexity and density of vegetation structure, especially in the shrub layers (Cody 1985, Saab 1995). Grazing by livestock can reduce plant density, change species composition, decrease plant vigor and productivity, and eliminate seedling establishment (from Krueper: Ryder 1980; Platts 1991; Horning 1994; Ohmart 1996;Belsky et al. 1999). These impacts can lower avian reproductive success, decrease food and nest site availability, and increase nest predation (Knopf et al. 1988, Bock et al 1993, Ammon and Stacey 1997).

Despite the utility of a simplified index and the known relationships between bird communities and grazing impacts in these systems, the BIBI should not be used uncritically to guide management decisions aimed at bird conservation. Declines in individual species may be masked by guild trends (Mannan et al 1984, Croonquist and Brooks 1991), and BIBI responsiveness to the disturbance gradient should not be substituted for understanding of underlying causal relationships. While birds show much promise as a taxonomic group for assessment purposes, there are several important limitations that should be considered. Birds are highly mobile organisms, whose populations are known to be influenced by factors affecting other parts of their year-round migratory range (Temple and Wiens 1989). Also, bird species populations vary regionally, so indices must be validated before they can be applied to new areas.

RECOMMENDATIONS

In continuing to develop and validate the BIBI in the future, we recommend several changes to the study design to improve the precision and utility of the index.

1. Increase the size of assessment area sampled for the disturbance gradient to include the entire wetland/riparian area, not just area immediately adjacent to the waterbody. Consider additional sampling along riparian areas to better match the scale of the bird survey transect.

2. One of the potential benefits of using the bird community as an indicator of overall condition, is the responsiveness of many bird species to changes at both the site and landscape scale. To incorporate larger scale stressors, we recommend stratifying site selection by watershed-level land use.

3. For new wetland types, we recommend sampling more sites to reduce the effects of natural variation.

FUTURE NEEDS

This study is a preliminary evaluation of the utility of the bird community as an assessment tool for wetland and riparian areas in Montana. There are several important steps that should be taken to finalize the BIBI and expand the index's utility:

1. Validate the BIBI using additional sites of the same wetland type. The original BIBI should be able to discriminate least and most impaired sites in a new data set.

2. The BIBI was developed to detect conditions influenced by livestock grazing. The applicability of the BIBI can be expanded by surveying sites with additional stressors.

3. Since the BIBI will be used to monitor interannual changes in wetlands, multiple years of field data should be added to calibrate the BIBI (U.S. EPA 2002).

4. Determine need for regional partitioning of data by comparing bird data from the same wetland type in other sub-basins and ecoregions. Classification is an iterative process, so classes may be lumped or split as needed to end up with biologically distinct wetlands. We expect that similar wetland groups in different watersheds and possibly ecoregions may be biologically similar enough to combine into one IBI in the future. For example, the BIBI was developed for headwater streams in the Montana Rocky Mountain ecoregion with the potential to support willow communities. Since many smaller order streams in the west have similar characteristics and support a similar bird community, it is likely that the BIBI will be applicable more widely.

5. For new data collected within the appropriate regional and wetland type classification (e.g. ecoregion), the index scoring range should be revised to fit the distribution of the combined data set (e.g. new 95th and 5th percentile values will be used for scoring sites. The index will continue to be improved as new data are incorporated into the index, especially as more sub-basins are sampled and a more representative coverage is obtained of the entire ecoregion.

II. Beaver Influence on Bird Communities

INTRODUCTION

Beaver (*Castor canadensis*) are considered ecosystem engineers, profoundly influencing aquatic functioning throughout North America (Naiman et al. 1988, Wright et al. 2002). The impoundment of free-flowing streams by beaver alter biogeochemical cycling, create and maintain wetlands, and increase sediment and organic matter deposition (Naiman et al. 1986).

These changes also broadly influence the composition and diversity of associated biotic communities on headwater streams, including riparian vegetation (Wright et al 2002), invertebrates (Clifford et al. 1993), amphibians (Metts et al. 2001), fish (Snodgrass and Meffe 1998), and mammals (Terwilliger and Pastor 1999). Several studies have also indicated a similar relationship between beaver activity and bird species composition. However, these studies have been restricted to forested regions in eastern North America (Reese and Hair 1976, Gibbs et al. 1991, Edwards and Otis 1999), have focused on single species groups (e.g. waterfowl: Beard 1953, Arner 1963, McCall 1996, and woodpeckers: Lochmiller 1979), or were limited to a single beaver complex (Medin and Clary 1990). There is little information on the influence of beaver on bird communities in the arid west, where riparian areas are particularly important to maintaining bird diversity (Knopf et al 1988).

Additionally, studies involving other taxa have found that the effect of beaver on biotic communities is highly dependent on the temporal dynamics of the activity (Schlosser and Kallemeyn 2000, Wright et al. 2002). Modification of aquatic ecosystems by beaver results in a shifting successional mosaic of habitats as streams are colonized, flooded, and eventually abandoned (Naiman et al. 1988, Johnston and Naiman 1990, Snodgrass 1997). When beavers build dams, the impounded waters create ponds and increase the area of riparian habitat by elevating the water table (Johnston and Naiman 1987). Riparian trees and shrubs are reduced through cutting and flooding (Johnston and Naiman 1987). After the dam is abandoned, the pond drains and the exposed sediments are colonized by herbaceous plants forming a “beaver meadow”, which is recolonized over time by trees and shrubs (Terwilliger and Pastor 1999, Wright et al. 2002).

The purpose of this study was to 1) examine the influence of beaver activity on bird assemblages and riparian habitat along headwater streams in southwestern Montana, 2) explore the influence of temporal variation of beaver activity, and 3) determine. the influence of beaver activity on the bird metrics included in a bird index of biological integrity (BIBI) we developed to assess riparian condition in the area.

METHODS

STUDY AREA

The study was conducted in the Red Rocks sub-basin (4^{th}-level U.S. Geological Survey hydrologic unit code 10020001), which is located in southwestern Montana (Fig. 2.1). The region is characterized by high elevation forests and intermontane valleys of sagebrush and grassland, with numerous mountain-fed perennial streams (CEC 1997). Riparian vegetation typically occurs as narrow bands of willow (*Salix spp.*) vegetation, with occasional small stands of Quaking aspen (*Populus tremuloides*). The climate is cool and semi-arid, with mean temperatures at Dillon ranging from 20.8º F in January to 65.8º F in July, and mean annual precipitation of 9.7 in (Western Regional Climate Center 2004).

SITE SELECTION

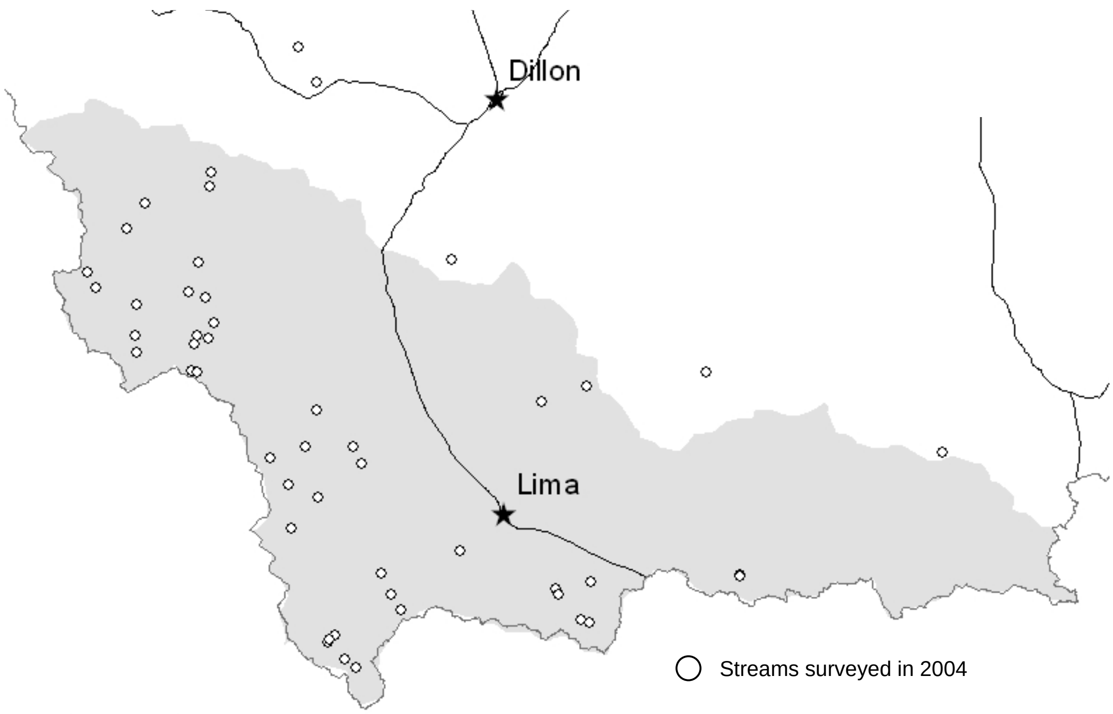
We surveyed riparian areas along first- and second-order streams with < 2 percent slope and the potential to support a willow-riparian community. Sites were selected from existing stream databases acquired from the Bureau of Land Management (BLM) and U.S. Forest Service (USFS), and a database containing beaver activity detected during amphibian surveys of all ponded water within selected watersheds (6^{th} level 4^{th}-level U.S. Geological Survey hydrologic unit code) in the region (Maxell 2004). All sites surveyed for the wetland assessment (see Section I, Methods, Site Selection) were included in this analysis. From Maxell's database, we selected all stream sites with evidence of beaver activity and meeting selection criteria (Fig. 2.1). In addition, we followed Maxell's (2004) methodology to locate all possible beaver-influenced sites in additional watersheds within the Red Rocks sub-basin using topographic maps and aerial photographs.

Beaver activity at each site was categorized into 3 levels: none (no evidence of beaver), old (collapsed ponds with evidence of past beaver activity, but no standing water), and active (ponds with functioning dam(s) retaining water). On streams with beaver activity, sites were located at the center of the beaver complex. Since beaver activity is often clustered on a single stream, we considered beaver activity as separate sites if they were >500 m apart. On sites without beaver activity, surveys were conducted within 15 m of the stream edge.

VEGETATION SAMPLING

We sampled tree density by species and size class and estimated tree canopy height within a 100-m radius plot located at the middle point count station of the bird survey transect. Shrub and ground cover were measured along three 100 m transects placed perpendicular to the stream (Fig. 2.2). Transects were 50 m apart, with the center vegetation transect crossing the bird survey point at the middle of the site. Shrub cover was sampled using the point intercept method every 2 m along each transect (Mueller-Dombois and Ellenberg 1974, Elzinga et al.1998). From these data we calculated the percent cover of shrubs by species in 4 height classes (<1 m, 1-2 m, 2-3 m, and >3 m). We also measured the proportion of shrubs with >50% live stems. Ground cover was estimated within 0.1 m^2 quadrats located at 10 m intervals along each transect. Ground cover was classified as grass, forb, sedge, rush, bare, rock, water, and other. Width of the riparian zone was sampled at the same location as each vegetation transect, and was measured from the outermost band of riparian vegetation on either side of the stream.

Figure 2.1. Map of Red Rocks study area and locations of streams surveyed in 2004 (several streams contain >1 site).



BIRD SAMPLING

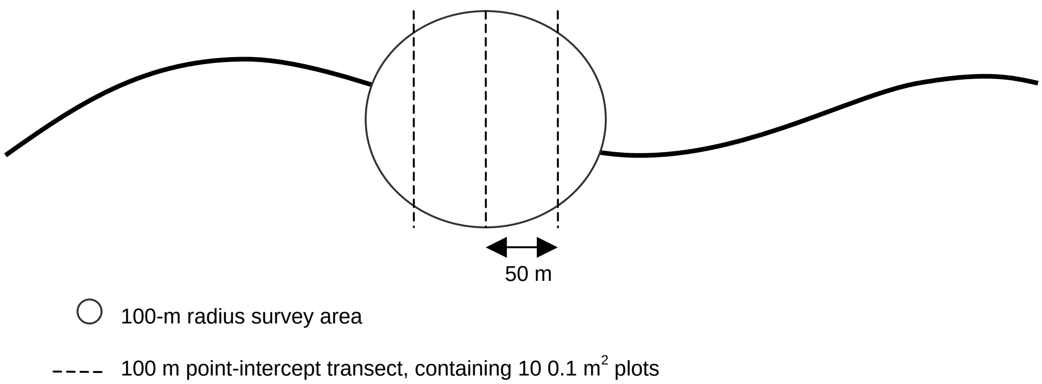
Sites were surveyed 2 times during the 2004 breeding season. We conducted a standard 10-min point count survey, where all birds detected by sight or sound within 100 m of the site center were recorded. All waterbirds flushed from the site upon arrival were also recorded. Bird surveys were conducted in the four hours after dawn, on days with minimal precipitation and wind <15 mph.

For analyses, we calculated relative abundance as the maximum abundance from the two survey days, and considered a species present if it was detected during at least 1 survey day. We considered the total number of bird species, or species richness, and a measure of diversity based on the abundance and evenness of species present. We used the Shannon index of diversity (*H'*), which is calculated as:

$$H' = -\sum_{i=1} p_i \ln p_i$$

The relative abundance of individual species detected in at least 25% of sites, and associated with riparian and wetland habitats in the region were also included in the analysis. Species were assigned to guilds based on diet, nest location, and foraging strategy as indicated in Ehrlich et al.(1988). Dietary preference metrics considered included insectivores, granivores, omnivores, and species relying on aquatic resources. Metrics based on foraging strategy included aerial foragers, ground gleaners, and foliage gleaners. We also considered native ground, shrub, tree, and cavity nesting species. Finally, we examined species groups, including the abundance of warblers, neotropical migrants, and riparian dependent or obligate species.

Figure 2.2. Diagram of bird and vegetation sampling scheme for riparian sites visited for beaver study in 2004.



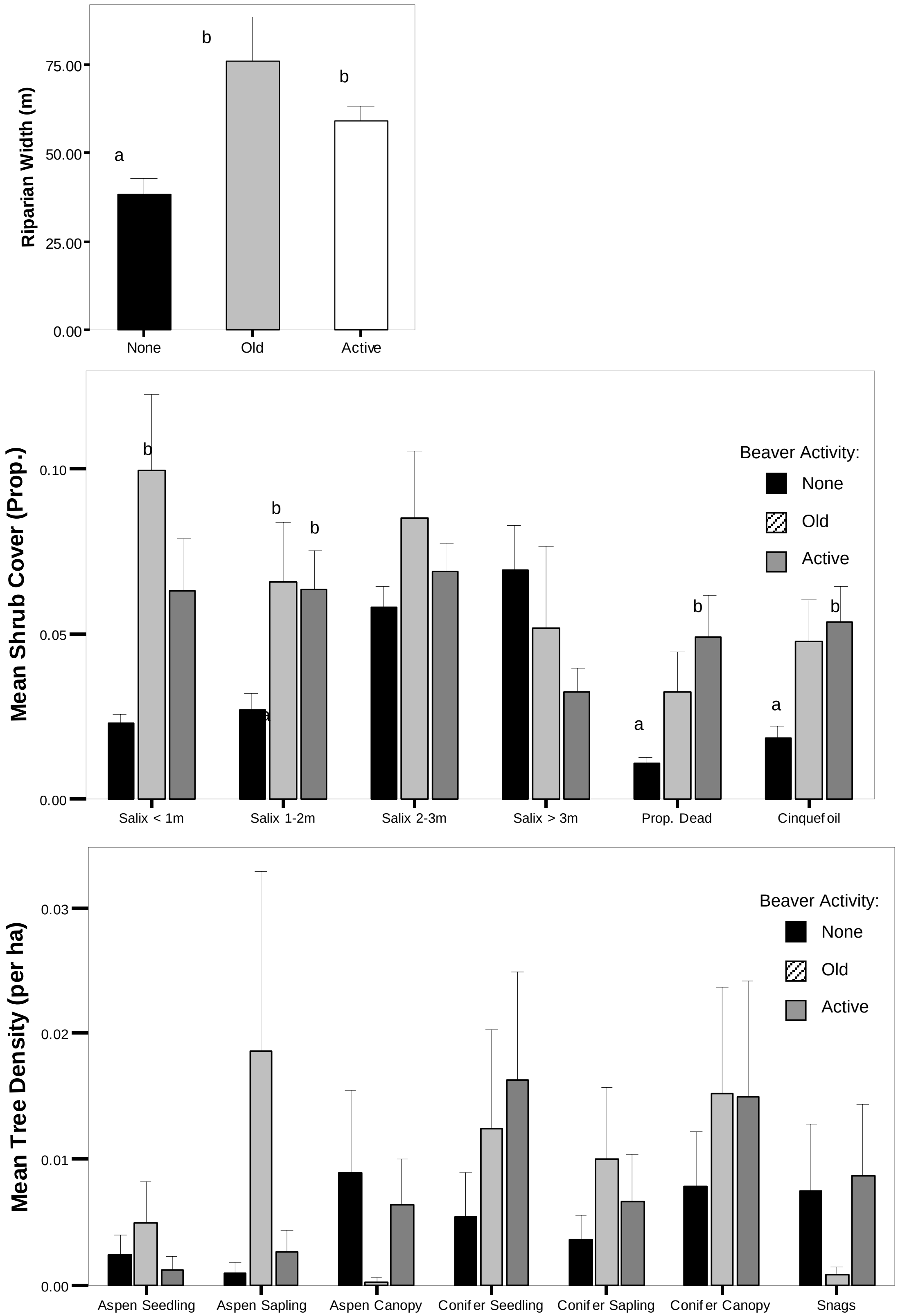
STATISTICAL ANALYSIS

We used a one-way analysis of variance (ANOVA) to detect differences in vegetation measures and relative bird abundance among beaver activity levels. When assumptions of the test were met, we used Tukey's post hoc comparison. If variances were heterogeneous among groups (Levene's test, $P > 0.05$), we assessed the equality of means using the robust Welch's test and Games-Howell post hoc comparison. SPSS software was used to perform all statistical analyses (SPSS 2003).

RESULTS

From 3 June to 16 July 2004, we surveyed 78 sites (43 none, 12 old, and 24 active) on 44 streams in southwestern Montana.

Figure 2.3. Vegetation measures, including riparian width, riparian shrub cover, and tree density across three levels of beaver activity (error bars represent SE).



Vegetation and Beaver Activity

The width of the riparian zone ranged from 9 to 183 m. Mean width of the riparian zone was significantly different across beaver activity levels (Welch's statistic, $P = 0.02$). On average, sites with old and active beaver activity had wider riparian zones than sites without ($P = 0.035$ and 0.004, respectively). The cover and structure of riparian shrubs also varied significantly among beaver classes ($P < 0.05$, Fig. 2.3). Mean cover of willow in two height classes (<1 m and 1-2 m) was significantly higher in sites with beaver activity. In addition the mean cover of cinquefoil (*Pentaphylloides floribunda*) and the proportion of dead willow stems was higher in active beaver sites than sites with none. Relative ground cover also differed among beaver activity levels (Fig. 2.4). In post hoc comparisons, water constituted a significantly greater percentage of ground cover on active beaver sites and sedges on both old and active sites, whereas grasses and forbs were significantly more abundant on sites without beaver activity ($P < 0.05$). There was no significant difference in tree densities among beaver activity levels for any size class (Table 2.1).

Figure 2.4. Mean percentages of relative ground cover across three levels of beaver activity

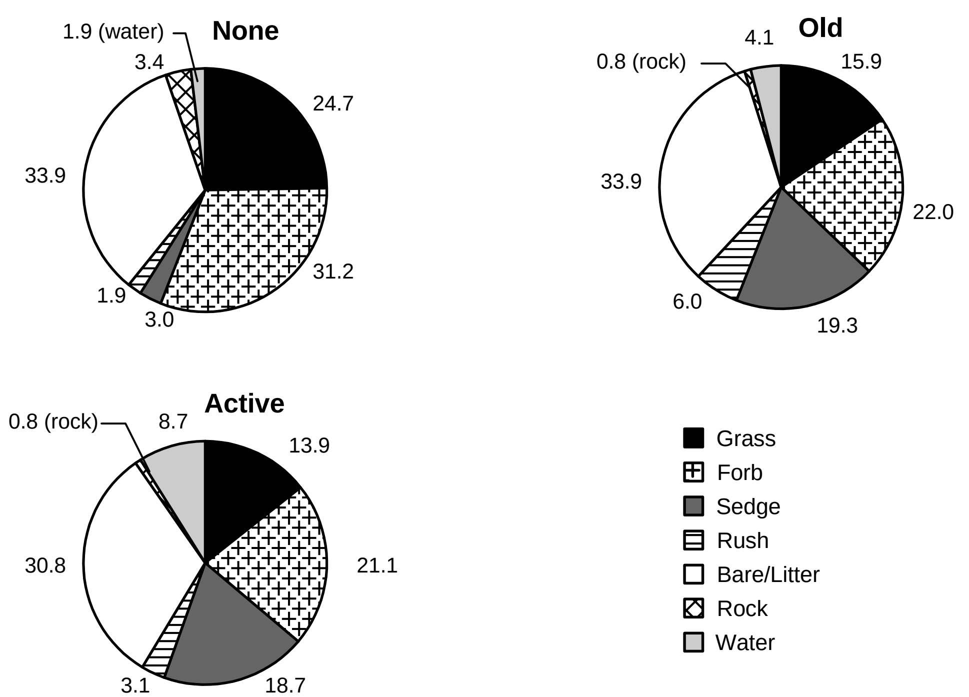


Table 2.1. Results of one-way analysis of variance of tree density variables and 3 beaver activity levels (Welch statistic used to test equality of means of variables with non-homogenous variance (Levene's statistic $P < 0.05$).

Variable	df	F	p
Aspen Seedling	2,76	0.658	0.521
Aspen Sapling[a]	2,76	-	-
Aspen Canopy	2,76	0.327	0.722
Conifer Seedling[b]	2,76	-	-
Conifer Sapling	2,76	0.850	0.432
Conifer Canopy	2,76	0.431	0.651
Snags	2,76	0.305	0.738

[a] Welch Statistic = 1.094, $P = 0.352$
[b] Welch Statistic = 0.872, $P = 0.430$

Bird Species Composition Relative to Beaver Activity

We detected a total of 77 bird species and 2,010 individuals. Yellow warblers, Warbling Vireos, and American Robins were the most abundant species detected (Appendix A.4). Eight species typically associated with wetland and riparian habitats were only found in old or active beaver sites: American Widgeon, Blue-winged Teal Belted Kingfisher, Mallard, Sandhill Crane, Wilson's Phalarope, Sora, Common Yellowthroat, and Willow Flycatcher (Appendix A.4).

Avian richness at a single site ranged from 5 to 23 species. However, avian species richness and diversity (H') did not differ significantly among beaver activity levels (ANOVA, $P = 0.07$ and $P = 0.08$, respectively, Fig. 2.5).

Figure 2.5. Mean species richness and Shannon's Diversity (*H'*) at three levels of beaver activity (error bars represent SE).

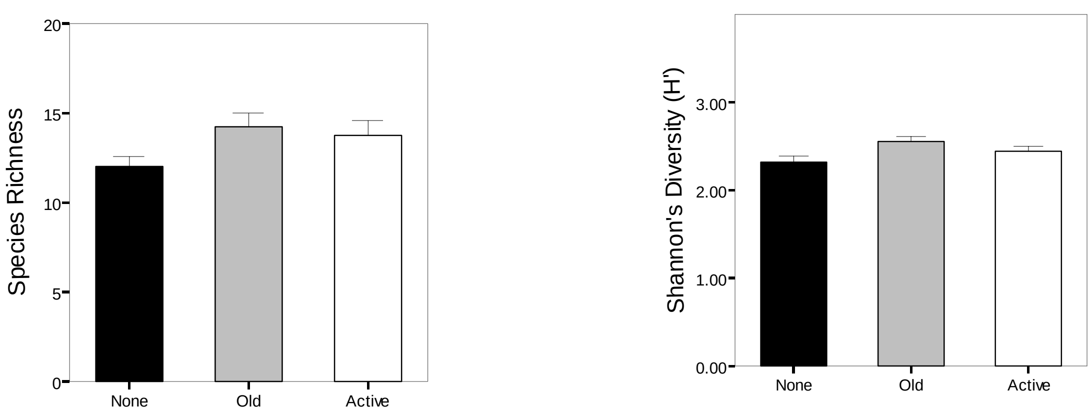
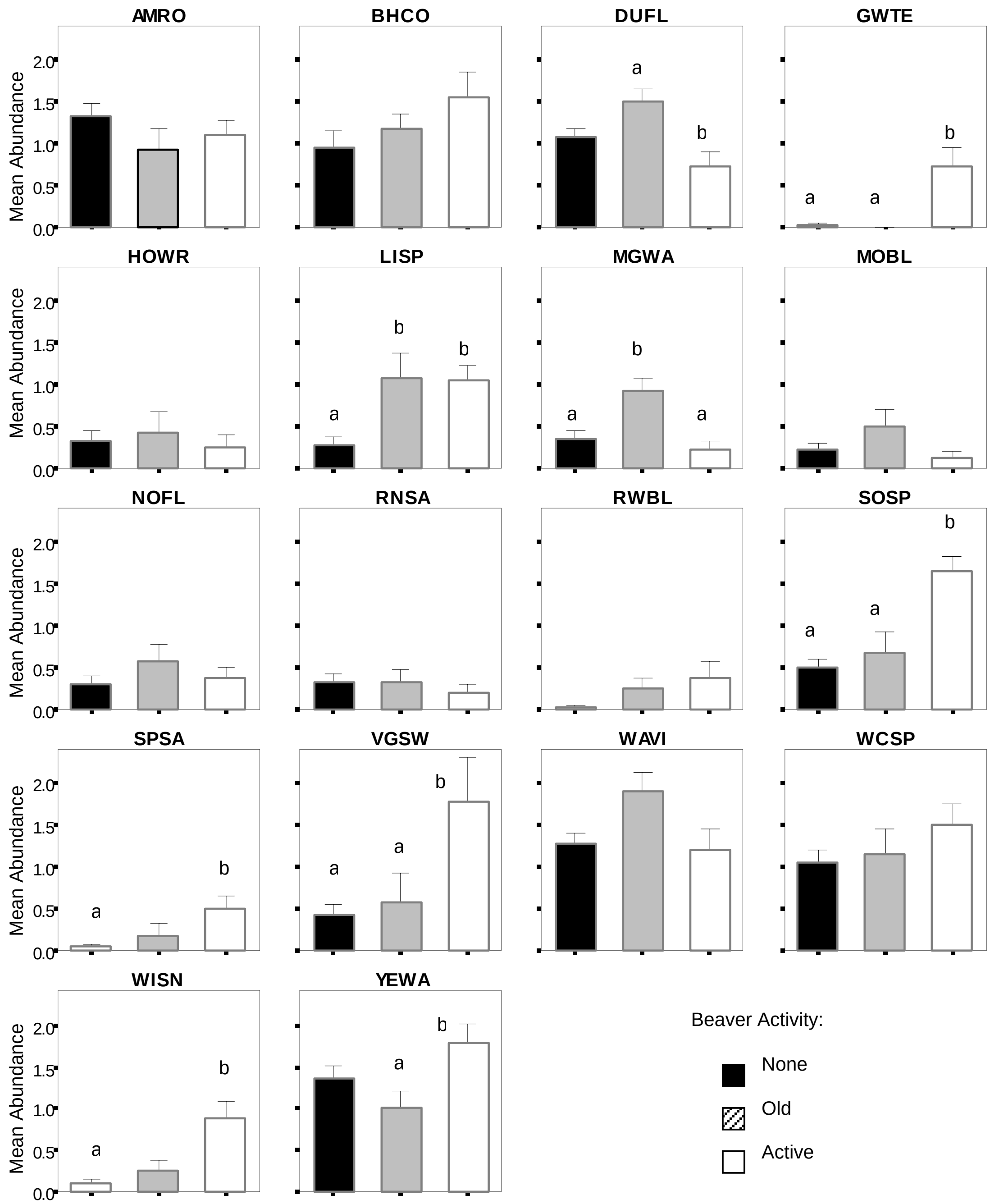


Figure 2.6. Mean abundance of 18 bird species at three levels of beaver activity. Error bars represent SE (species codes listed in Appendix ?). Beaver classes with different letter designations (i.e. *a* or *b*) indicate a significant difference in post hoc comparisons ($P < 0.05$).



Eighteen riparian associated species occurred at a sufficient number of sites to be included in analysis. Of these, the mean abundance of 9 species differed significantly across the three beaver activity levels (One-way ANOVA $P < 0.05$, Fig 2.6). With the exception of Dusky Flycatchers, these species were significantly more abundant in old and/or active beaver sites than sites with no beaver activity. The mean abundance of six of the response guilds and species groups considered in analysis were also significantly different across the three beaver activity levels: aquatic diet, ground nesters, aerial foragers, ground gleaners, neotropical migrants, and riparian obligate/dependents (One-way ANOVA $P < 0.05$, Fig. 2.7). All had higher mean abundances in sites with old and/or active beaver activity than in sites without.

Figure 2.7. Mean abundance of response guilds and species groups at three levels of beaver activity (error bars represent SE). Beaver classes with different letter designations (i.e. *a, b* or *c*) indicate a significant difference in post hoc comparisons ($P < 0.05$).

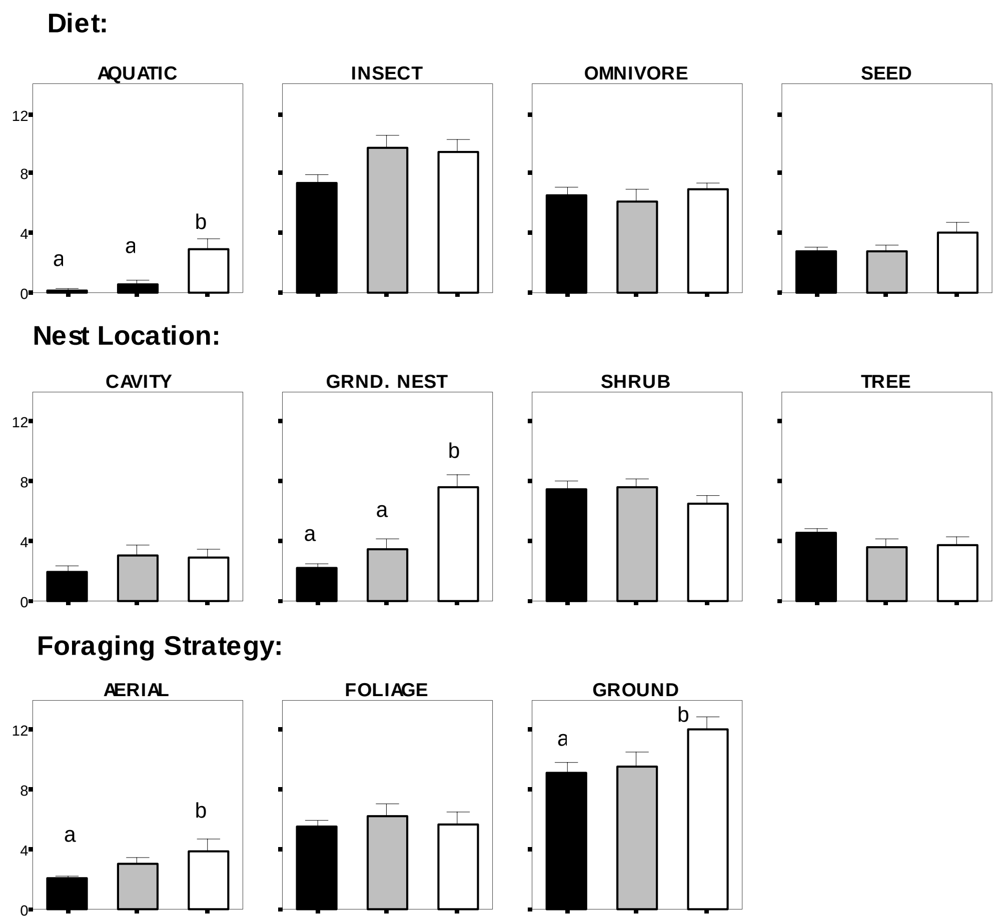
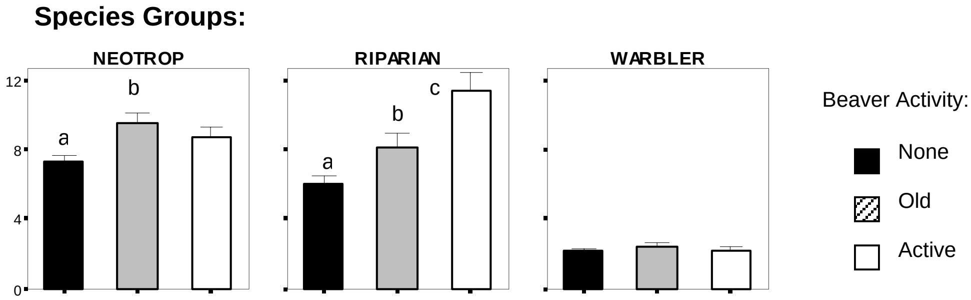


Figure 2.7 Continued.



DISCUSSION

Beaver activity has a profound influence on the structure and productivity of the riparian zone (Naiman et al. 1988). Furthermore, above river valley bottoms the majority of available lentic habitat in southwestern Montana is created and maintained by beaver (Maxell, 2004). Therefore, beaver activity is an important consideration in the conservation of wetland and riparian function in this region.

Our findings suggest that beaver significantly influence both the riparian habitat and the associated bird communities on headwater streams in southwestern Montana. The majority of riparian-associated bird species in this study were more abundant at beaver influenced sites than sites without beaver. In our study, streams with recent beaver activity typically had more surface water and a higher proportion of dead willow. With few exceptions, all waterfowl species and the majority of shorebirds were detected on beaver-influenced sites.

Furthermore, many bird species in our study responded uniquely to areas with evidence of recent versus older beaver activity. Once a beaver site is no longer active, dams deteriorate, and ponds are replaced by “beaver meadows”, and eventually young riparian vegetation (Wright 2002). We found that older beaver sites, as would be expected, have a higher percentage of small size class willow cover, a wider riparian zone than non-beaver influenced, and a high percentage of emergent vegetation such as sedges and grasses. While the MacGillivray’s Warbler was the only species that was statistically most abundant in old beaver sites, several other species showed a similar association older beaver activity (e.g. Dusky Flycatcher, Spotted Sandpipers, and Warbling Vireos). In addition, neotropical migrants were highest in sites with older beaver activity.

As far as we know, this is the first published study of the relationship between beaver and birds across more than one stream in western North America. Previous studies in forested regions in the east have also found beaver ponds support greater diversity and abundance of birds (Reese and Hair, 1976, Edwards and Otis 1999), and are important breeding habitat for waterfowl (Beard 1953, Arner 1963, McCall 1996). In east-central Idaho, similar relationships for many of the species included in our study were found in a comparison of a single beaver pond to an adjacent section of stream by Medin and Clary (1990).

Implications for Biological Assessments
Three of the metrics included in the BIBI we developed for the region were significantly influenced by beaver activity: aerial foragers, neotropical migrants, and riparian obligate/dependents. These metrics are therefore are unlikely to follow expected relationships with human disturbance unless beaver activity is accounted for.

Natural disturbances, such as beaver, present challenges for interpreting assessments developed to measure human impacts on wetland condition, since beaver activity substantially alter the hydrology, biogeochemistry, and biotic communities. However, incorporating beaver influence into watershed scale measures of wetland condition is essential, since beaver have such a profound role in the functioning of riparian and wetland areas.

RECOMMENDATIONS

- The successional mosaic created by beaver activity has both temporal and spatial components (Naiman et al. 1988), and birds are likely influenced by spatial variation in beaver activity across the landscape. Therefore, we recommend future studies also include the influence of spatial variation in beaver activity.

- We recommend measuring disturbance variables used to develop the BIBI at the beaver-influenced sites to examine potential interactions between beaver and grazing impacts.

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Appendix A: Bird Survey Data 2003-2004

Table A.1. Bird species observed, and number of individuals counted during point counts and area searches in Middle Milk depressional and riparian areas during 2003.

	Depressional		Riparian	
Species	Point Count	Area Search	Point Count	Area Search
American Avocet	2	2	4	2
American Widgeon	0	0	3	5
Baird's Sparrow	0	0	21	13
Brown-headed Cowbird	0	2	41	16
Brewer's Blackbird	2	8	10	10
Brewer's Sparrow	0	1	4	25
Brown Thrasher[2]	0	0	5	3
Canada Goose	2	0	0	0
California Gull	0	0	0	1
Chestnut-collared Longspur	28	24	7	6
Clay-colored Sparrow	0	0	5	6
Cliff Swallow	0	0	7	1
Common Merganser	0	0	4	0
Common Nighthawk	0	1	1	1
Common Snipe[1]	1	1	1	2
Common Yellowthroat	0	0	5	7
Eastern Kingbird	0	0	8	5
European Starling	0	0	2	1
Franklin's Gull	0	1	0	0
Grasshopper Sparrow	0	0	6	4
Green-winged Teal[1]	0	1	0	0
Horned Lark	12	12	38	13
Killdeer	2	2	11	10
Lark Bunting	9	9	57	30
LeConte's Sparrow	0	0	1	1
Loggerhead Shrike[2]	0	0	1	0
Marbled Godwit	4	0	7	8
Mallard Duck	0	2	4	12
Mourning Dove	1	0	7	6
Northern Harrier	1	0	1	1
Northern Pintail[1]	3	2	1	11
Rock Wren	0	0	1	0
Red-tailed Hawk	0	0	0	1
Red-winged Blackbird	6	22	41	46
Say's Phoebe	0	0	4	2
Savannah Sparrow	21	33	21	30
Short-eared Owl	2	1	0	0
Shovelor Duck	0	0	2	0
Vesper Sparrow	0	0	19	12
Western Kingbird	0	0	1	1
Western Meadowlark	17	9	57	38
Willet	7	8	5	4
Wilson's Phalarope	5	15	5	2

Table A.1. Continued

Species	Depressional Point Count	Depressional Area Search	Riparian Point Count	Riparian Area Search
Yellow Warbler[2]	0	0	2	2
Yellow-headed Blackbird[1]	3	14	0	0
Total	133	171	441	384

[1] Species detected at a single depressional site with standing water
[2] Species detected at a single riparian site with cottonwoods and riparian shrubs

Table A.2. Bird species observed, and number of individuals counted during point counts and area searches in Red Rocks riparian areas during 2003.

Species	Riparian Point Count	Riparian Area Search
American Crow	7	2
American Kestral	1	1
American Robin	49	30
Black-billed Magpie	27	7
Black-capped Chickadee	4	5
Belted Kingfisher[1]	0	1
Brown-headed Cowbird	26	21
Brewer's Blackbird	30	8
Brewer's Sparrow	24	22
Chipping Sparrow	2	2
Cliff Swallow[1]	0	1
Clark's Nutcracker[2]	1	0
Common Snipe	7	2
Common Yellowthroat	1	1
Dark-eyed Junco	15	9
Downy Woodpecker[1]	0	1
Dusky Flycatcher	44	33
Eastern Kingbird[2]	1	0
Green-tailed Towhee	3	2
Hammond's Flycatcher[2]	1	0
Hermit Thrush[2]	1	0
House Wren	7	4
Killdeer	6	4
Long-billed Curlew	14	3
Lazuli Bunting[1]	0	2
MacGillivray's Warbler	6	5
Mountain Bluebird	6	4
Mountain Chickadee	14	14
Mourning Dove	3	2
Northern Flicker	11	7
Red-breasted Nuthatch	3	2
Ruby-crowned Kinglet	8	3
Red-naped Sapsucker	1	1
Rock Wren	6	6

Table A.2. Continued.

Species	Riparian Point Count	Area Search
Red-tailed Hawk	2	1
Red-wing Blackbird	2	1
Savannah Sparrow	7	1
Sandhill Crane	15	11
Song Sparrow	30	27
Spotted Sandpiper[1]	0	3
Townsend's Solitaire[1]	0	1
Empidonax spp.	6	6
Veery	7	3
Vesper Sparrow	45	17
Violet-green Swallow[1]	2	2
Warbling Vireo	47	44
White-crowned Sparrow	21	16
Western Meadowlark	10	3
Western Tanager[1]	0	3
Western Wood-peewee[2]	3	0
Willow Flycatcher	4	4
Yellow Warbler	73	69
Yellow-rumped Warbler	7	6
Total	628	436

[1] Species detected only during Area Search surveys
[2] Species detected only during Point Count surveys

Table A.3. Abundance, guild assignments, migratory status, and species groupings for bird species detected during surveys for BIBI development in 2004 in the Red Rocks study area.

Species	Abundance	Nest Type[a]	Diet[b]	Foraging Type[c]	Neotropical Migrant	Riparian	Warbler
American Goldfinch	4	SH	GRA	FG	N	Y	N
American Kestral	2	CA	NA	AF	N	N	N
American Robin	169	TR	OM	GG	N	N	N
Black-billed Magpie	9	TR	OM	GG	N	N	N
Black-capped Chickadee	19	CA	IN	NA	N	Y	N
Belted Kingfisher	1	NA	NA	NA	N	Y	N
Brown-headed Cowbird	99	NA	OM	GG	N	N	N
Blue Grouse	1	GR	OM	GG	N	N	N
Brewer's Blackbird	25	NA	OM	GG	N	N	N
Brewer's Sparrow	54	SH	OM	GG	Y	N	N
Cassin's Finch	1	TR	GRA	GG	N	N	N
Calliope Hummingbird	1	TR	NA	NA	Y	Y	N
Canvasback	1	GR	NA	NA	N	Y	N
Cedar Waxwing	4	TR	NA	FG	N	N	N
Chipping Sparrow	51	TR	OM	GG	Y	N	N
Clark's Nutcracker	9	TR	GRA	FG	N	N	N
Cliff Swallow	30	NA	IN	AF	Y	N	N
Cordilleran Flycatcher	1	TR	IN	AF	Y	Y	N
Dark-eyed Junco	34	GR	GRA	GG	N	N	N
Downy Woodpecker	4	CA	IN	NA	N	N	N
Dusky Flycatcher	174	SH	IN	AF	Y	N	N
Eastern Kingbird	1	TR	IN	AF	Y	Y	N
Grey Catbird	7	SH	OM	GG	Y	Y	N
Green-tailed Towhee	17	SH	OM	GG	Y	N	N
Hammond's Flycatcher	1	TR	IN	AF	Y	N	N
Horned Lark	2	GR	GRA	GG	Y	N	N
House Wren	21	CA	IN	GG	Y	Y	N
Killdeer	2	GR	IN	GG	N	N	N
Lazuli Bunting	16	SH	OM	GG	N	Y	N
Lincoln Sparrow	54	GR	OM	GG	Y	Y	N
Mallard	4	GR	NA	NA	N	Y	N
MacGillivray's Warbler	43	SH	IN	FG	Y	Y	Y
Mountain Bluebird	15	CA	IN	GG	N	N	N
Mountain Chickadee	7	CA	IN	FG	N	N	N
Mourning Dove	7	TR	GRA	GG	N	N	N
Northern Flicker	17	CA	IN	GG	N	N	N
Northern Rough-winged Swallow	4	GR	IN	AF	Y	N	N
Orange Crowned Warbler	4	GR	IN	FG	Y	Y	Y
Pine Siskin	110	TR	GRA	FG	N	N	N
Red-breasted Nuthatch	2	CA	OM	NA	N	N	N
Ruby-crowned Kinglet	13	TR	IN	FG	N	N	N
Red-naped Sapsucker	18	CA	OM	NA	N	Y	N
Rock Wren	14	GR	IN	GG	N	N	N
Say's Phoebe	1	GR	IN	AF	N	N	N
Song Sparrow	48	GR	OM	GG	N	Y	N

Table A.3 Continued.

Species	Abundance	Nest Type[a]	Diet[b]	Foraging Type[c]	Neotropical Migrant	Riparian	Warbler
Spotted Sandpiper	15	GR	NA	GG	N	Y	N
Spotted Towhee	1	GR	NA	GG	N	N	N
Townsend's Warbler	3	TR	OM	AF	N	N	N
Tree Swallow	8	CA	IN	AF	N	Y	N
Veery	2	GR	OM	GG	Y	Y	N
Vesper Sparrow	23	GR	OM	GG	N	N	N
Violet-green Swallow	11	CA	IN	AF	Y	Y	N
Warbling Vireo	162	SH	IN	FG	Y	Y	N
White-crowned Sparrow	92	SH	GRA	GG	N	N	N
Western Meadowlark	4	GR	OM	GG	N	N	N
Western Tanager	14	TR	IN	FG	Y	N	N
Western Wood-peewee	3	TR	IN	AF	Y	Y	N
Willow Flycatcher	1	SH	IN	AF	Y	Y	N
Williamson's Sapsucker	1	CA	IN	NA	N	N	N
Wilson's Snipe	5	GR	NA	GG	Y	Y	N
Wilson's Warbler	14	GR	IN	FG	Y	Y	Y
Yellow Warbler	199	SH	IN	FG	Y	Y	Y
Yellow-rumped Warbler	41	TR	IN	FG	Y	N	Y
Total Abundance	1720						

[a] Nest type: CA (cavity nester), GR (ground nester), NA(nest type not considered for index), SH (shrub nester), and TR (tree nester)
[b] Diet: GRA (granivore), IN (insectivore), NA (diet type not considered for index), and OM (omnivore)
[c] Foraging type: AF (aerial forager), FG (foliage gleaner), GG (ground gleaner), and NA (foraging type not considered for index)

Table A.4. Abundance by beaver activity level, guild assignments, migratory status, and species groupings for bird species detected during surveys in 2004 in southwestern Montana.

Species Name	Species Code	None	Old	Active	Total	Nest Type[a]	Diet[b]	Foraging Type[c]	Neotropical Migrant	Riparian/ Wetland	Warbler
Alder Flycatcher	ALFL	0	0	1	1	GR	IN	AF	Y	N	N
American Crow	AMCR	1	0	0	1	TR	OM	GG	N	N	N
American Goldfinch	AMGO	2	0	4	6	SH	GRA	FG	N	Y	N
American Kestral	AMKE	1	1	0	2	CA	NA	AF	N	N	N
American Robin	AMRO	54	11	26	91	TR	OM	GG	N	N	N
American Widgeon	AMWI	0	0	1	1	GR	AQ	NA	N	Y	N
Black-billed Magpie	BBMA	6	0	2	8	TR	OM	GG	N	N	N
Black-capped Chickadee	BCCH	2	0	0	2	CA	IN	NA	N	Y	N
Belted Kingfisher	BEKI	0	0	1	1	NA	NA	NA	N	Y	N
Brown-headed Cowbird	BHCO	38	14	37	89	NA	OM	GG	N	N	N
Brewer's Blackbird	BRBL	47	5	6	58	NA	OM	GG	N	N	N
Brewer's Sparrow	BRSP	26	7	14	47	SH	OM	GG	Y	N	N
Blue-winged Teal	BWTE	0	0	1	1	GR	AQ	NA	N	Y	N
Cassin's Finch	CAFI	2	0	3	5	TR	GRA	GG	N	N	N
Calliope Hummingbird	CAHU	6	0	3	9	TR	NA	NA	Y	Y	N
Cedar Waxwing	CEWA	3	0	1	4	TR	NA	FG	N	N	N
Chipping Sparrow	CHSP	12	6	4	22	TR	OM	GG	Y	N	N
Clark's Nutcracker	CLNU	9	3	2	14	TR	GRA	FG	N	N	N
Cliff Swallow	CLSW	1	0	22	23	NA	IN	AF	Y	N	N
Cordilleran Flycatcher	COFL	3	0	0	3	TR	IN	AF	Y	Y	N
Common Raven	CORA	0	0	2	2	TR	OM	GG	N	N	N
Common Yellowthroat	COYE	0	1	0	1	TR	IN	AF	Y	Y	Y
Dark-eyed Junco	DEJU	11	5	8	24	GR	GRA	GG	N	N	N
Dusky Flycatcher	DUFL	44	18	17	79	SH	IN	AF	Y	N	N
European Starling	EUST	3	0	0	3	NA	IN	GG	N	N	N
Ferruginous Hawk	FEHA	2	0	0	2	NA	NA	NA	N	N	N
Great-horned Owl	GHOW	1	0	0	1	TR	NA	NA	N	N	N
Grey Catbird	GRCA	3	0	0	3	SH	OM	GG	Y	Y	N
Green-tailed Towhee	GTTO	9	0	1	10	SH	OM	GG	Y	N	N
Green-winged Teal	GWTE	2	0	17	19	GR	AQ	NA	N	Y	N
Horned Lark	HOLA	1	0	0	1	GR	GRA	GG	Y	N	N
House Wren	HOWR	13	5	6	24	CA	IN	GG	Y	Y	N

Table A.4 continued**.**

Species Name	Species Code	None	Old	Active	Total	Nest Type[a]	Diet[b]	Foraging Type[c]	Neotropical Migrant	Riparian/ Wetland	Warbler
Killdeer	KILL	0	0	4	4	GR	IN	GG	N	N	N
Lazuli Bunting	LAZB	6	2	0	8	SH	OM	GG	N	Y	N
Lincoln Sparrow	LISP	11	13	25	49	GR	OM	GG	Y	Y	N
Mallard	MALL	0	1	13	14	GR	NA	NA	N	Y	N
MacGillivray's Warbler	MGWA	14	11	5	30	SH	IN	FG	Y	Y	Y
Mountain Bluebird	MOBL	9	6	3	18	CA	IN	GG	N	N	N
Mountain Chickadee	MOCH	3	5	6	14	CA	IN	FG	N	N	N
Mourning Dove	MODO	0	1	0	1	TR	GRA	GG	N	N	N
Northern Flicker	NOFL	12	7	9	28	CA	IN	GG	N	N	N
Northern Harrier	NOHA	1	0	0	1	NA	NA	NA	N	N	N
Northern Rough-winged Swallow	NRWS	1	0	2	3	GR	IN	AF	Y	N	N
Orange Crowned Warbler	OCWA	4	3	1	8	GR	IN	FG	Y	Y	Y
Pine Siskin	PISI	44	10	36	90	TR	GRA	FG	N	N	N
Prairie Falcon	PRFA	0	0	1	1	NA	NA	NA	N	N	N
Red-breasted Nuthatch	RBNU	0	0	1	1	CA	OM	NA	N	N	N
Ruby-crowned Kinglet	RCKI	8	1	2	11	TR	IN	FG	N	N	N
Red Crossbill	RECR	3	1	0	4	TR	GRA	FG	N	N	N
Red-naped Sapsucker	RNSA	13	4	5	22	CA	OM	NA	N	Y	N
Rock Wren	ROWR	16	0	2	18	GR	IN	GG	N	N	N
Red-tailed Hawk	RTHA	1	0	4	5	NA	NA	NA	N	N	N
Red-winged Blackbird	RWBL	1	3	9	13	GR	GRA	GR	N	Y	N
Sandhill Crane	SACR	0	0	4	4	GR	OM	GR	N	Y	Y
Say's Phoebe	SAPH	1	0	0	1	GR	IN	AF	N	N	N
Sage Thrasher	SATH	2	0	0	2	GR	IN	GR	N	N	N
Savannah Sparrow	SAVS	1	0	5	6	GR	GRA	GR	N	N	N
Sora	SORA	0	0	2	2	GR	AQ	GR	N	Y	N
Song Sparrow	SOSP	21	8	40	69	GR	OM	GG	N	Y	N
Spotted Sandpiper	SPSA	2	2	12	16	GR	AQ	GR	N	Y	N
Sharp-shinned Hawk	SSHA	0	1	0	1	NA	NA	NA	N	N	N
Townsend's Solitaire	TOSO	1	1	0	2	TR	OM	AF	N	N	N
Veery	VEER	2	0	0	2	GR	OM	GR	Y	Y	N

Table A.4 continued.

Species Name	Species Code	None	Old	Active	Total	Nest Type[a]	Diet[b]	Foraging Type[c]	Neotropical Migrant	Riparian/ Wetland	Warbler
Vesper Sparrow	VESP	2	3	1	6	GR	OM	GR	N	N	N
Violet-green Swallow	VGSW	20	8	41	69	CA	IN	AF	Y	Y	N
Warbling Vireo	WAVI	51	23	29	103	SH	IN	FG	Y	Y	N
White-crowned Sparrow	WCSP	42	14	36	92	SH	GRA	GG	N	N	N
Western Meadowlark	WEME	6	0	6	12	GR	OM	GG	N	N	N
Western Tanager	WETA	10	3	2	15	TR	IN	FG	Y	N	N
Western Wood-peewee	WEWP	6	2	0	8	TR	IN	AF	Y	Y	N
Willow Flycatcher	WIFL	0	0	2	2	SH	IN	AF	Y	Y	N
Wilson's Phalarope	WIPH	0	0	1	1	GR	AQ	GR	N	Y	N
Wilson's Snipe	WISN	4	3	21	28	GR	NA	GG	Y	Y	N
Wilson's Warbler	WIWA	1	0	1	2	GR	IN	FG	Y	Y	Y
Yellow Warbler	YEWA	56	12	43	111	SH	IN	FG	Y	Y	Y
Yellow-rumped Warbler	YRWA	10	3	3	16	TR	IN	FG	Y	N	Y

[a] Nest type: CA (cavity nester), GR (ground nester), NA(nest type not considered for index), SH (shrub nester), and TR (tree nester)
[b] Diet: AQ (aquatic insects/plants), GRA (granivore), IN (insectivore), NA (diet type not considered for index), and OM (omnivore)
[c] Foraging type: AF (aerial forager), FG (foliage gleaner), GG (ground gleaner), and NA (foraging type not considered for index)

Appendix B. Metric and Bibi Scores

Table B.1. Standardized bird metrics and BIBI scores for all sites surveyed in the Red Rocks study area in 2004 (note: scores were also calculated for sites without disturbance gradient scores, and therefore not included in the index development).

Site ID	Stream Name	Condition	Disturbance Gradient	Insectivore Score	Shrb Nest Score	Warbler Score	Neotrop Score	Riparian Score	BIBI Score
PRICE_MF	Middle Fork Price	PFC	0.20	100.0	100.0	100.0	100.0	100.0	100.0
GRIMES	Grimes	FAR	.	100.0	100.0	25.2	73.7	77.5	75.3
BLCKT_EF	East Fork Blacktail	PFC	0.34	71.8	50.0	67.2	71.4	97.6	71.6
FRYPAN	Frying Pan	FAR	.	74.3	75.0	46.2	80.6	70.0	69.2
BEAR	Bear	PFC	.	56.9	87.5	37.8	71.4	75.0	65.7
EVERSN_NF	North Fork Everson	PFC	0.15	74.3	87.5	42.0	62.2	30.0	59.2
LSHEEP	Little Sheep	NF	0.57	65.0	62.5	36.8	66.2	46.9	55.5
BLKCAN	Black Canyon	PFC	0.25	54.5	75.0	33.6	59.9	52.5	55.1
CAMP	Camp	FAR	0.53	54.5	75.0	33.6	59.9	47.5	54.1
MAD_WF	West Fork Madison	FAR	.	39.6	87.5	46.2	43.8	50.0	53.4
MCNIN	McNinch	FAR	0.33	49.5	87.5	21.0	59.9	40.0	51.6
NICHOL_LW	Nicholia	PFC	0.72	49.5	62.5	54.6	50.7	37.5	51.0
HRSPRIE	Horse Prairie	PFC	0.16	47.0	75.0	33.6	48.4	50.0	50.8
NICHOL	Lower Nicholia	PFC	0.48	52.0	62.5	42.0	53.0	27.5	47.4
DEADMN	Deadman	PFC	.	44.6	87.5	21.0	39.2	35.0	45.5
TAYLOR	Taylor	FAR	0.21	49.5	50.0	46.2	39.2	40.0	45.0
TENDOY	Tendoy	FAR	0.52	44.6	75.0	33.6	48.4	22.5	44.8
MORRISON	Morrison	FAR	0.76	44.6	75.0	29.4	46.1	27.5	44.5
LBEAV	Little Beaver	FAR	0.35	41.5	75.0	26.3	47.8	28.8	43.9
BLCKT_WF	West Fork Blacktail	NF	0.76	44.6	50.0	29.4	48.4	45.0	43.5
WATSN_SFL	South Fork Watson	FAR	0.46	64.4	62.5	8.4	41.5	35.0	42.4
DYCE	Dyce	PFC	.	52.0	50.0	16.8	41.5	30.0	38.1
CABIN	Cabin	FAR	.	29.7	62.5	16.8	41.5	25.0	35.1
LAW	Law	NF	.	24.8	75.0	12.6	39.2	20.0	34.3
MUD_TR	Muddy Tributary	NF	0.69	32.2	75.0	4.2	36.9	20.0	33.7

Table B.1 continued.

Site ID	Stream Name	Condition	Disturbance Gradient	Insectivore Score	Shrb Nest Score	Warbler Score	Neotrop Score	Riparian Score	BIBI Score
RAPE	Rape	NF	0.85	43.9	50.0	13.7	19.6	25.0	30.4
COW	Cow	NF	0.41	22.3	62.5	8.4	34.6	17.5	29.1
SHENON	Shenon	FAR	0.64	32.2	50.0	16.8	25.3	20.0	28.9
BGHOLL	Big Hollow	FAR	1.00	32.2	37.5	21.0	30.0	20.0	28.1
WATSN_SFU	South Fork Watson	NF	0.90	37.1	50.0	8.4	23.0	20.0	27.7
LSAGE	Little Sage	FAR	0.73	9.9	50.0	12.6	18.4	12.5	20.7
LSAGE_TR	Little Sage Tributary	NF	0.33	9.0	50.0	4.0	15.0	9.0	17.0
INDIAN[a]	Indian	FAR	0.00	.	.	.	.	.	.

[a] INDIAN was excluded from analyses.

Appendix C. Task 4 Report: Analyses and Procedure Revisions

Based on discussions at the December 2003 working group meeting, we will not continue bird studies in the Middle Milk Study area in 2004. Therefore, we only used data collected in Red Rocks in analyses to inform changes in bird survey procedures.

Point Counts

Point count surveys were conducted at 3 point count stations (see the QAPP for a complete explanation of procedures). Data from the 3 stations were summed into a single list of species and abundances for each stream site. For species present at a site, the average abundance of individual species ranged from 1 for rare species to 7 for the American crow, a flocking species (Table C.1). These abundance measures are considered low for making reliable comparisons of abundance. Therefore, we suggest adding point count stations to increase the number of bird detections at a site, which will improve metrics based on bird abundance.

Table C.1. Average abundance of species from point count surveys at Red Rocks sites where species was present.

Species	n[1]	Mean Abundance
American Crow	1	7.0
Yellow Warbler	14	5.2
Brewer's Blackbird	9	4.3
Long-billed Curlew	1	4.0
Warbling Vireo	12	3.9
Sandhill Crane	2	3.8
Savannah Sparrow	4	3.5
Black-billed Magpie	8	3.4
Vesper Sparrow	14	3.2
Dusky Flycatcher	15	3.1
Brewer's Sparrow	7	3.0
Brown Creeper	1	3.0
Killdeer	2	3.0
American Robin	18	2.9
Brown-headed Cowbird	8	2.9
Common Snipe	3	2.7
Song Sparrow	12	2.6
Western Meadowlark	10	2.5
Mountain Chickadee	7	2.4
House Wren	4	2.3
White-crowned Sparrow	2	2.1
Red-tailed Hawk	1	2.0
Rock Wren	1	2.0

Table C.3 Continued

Species	n[1]	Mean Abundance
White-crowned Sparrow	2	2.1
Red-tailed Hawk	1	2.0
Rock Wren	1	2.0
Yellow-rumped Warbler	5	2.0
Dark-eyed Junco	10	1.8
Veery	4	1.8
Unknown Empidonax spp.	3	1.7
Green-tailed Towhee	2	1.5
MacGillivray's Warbler	4	1.5
Mountain Bluebird	4	1.5
Mourning Dove	2	1.5
Red-breasted Nuthatch	2	1.5
Ruby-crowned Kinglet	2	1.5
Western Wood-peewee	4	1.5
Black-capped Chickadee	3	1.3
Northern Flicker	10	1.2
American Kestral	1	1.0
Chipping Sparrow	2	1.0
Clark's Nutcracker	1	1.0
Common Yellowthroat	1	1.0
Eastern Kingbird	1	1.0
Hammond's Flycatcher	1	1.0
Hermit Thrush	1	1.0
Red-naped Sapsucker	6	1.0
Red-wing Blackbird	3	1.0
Spotted Sandpiper	1	1.0
Violet-green Swallow	3	1.0
Willow Flycatcher	4	1.0

n[1] =the number of sites where species were detected

Increasing the number of point count stations requires either increasing the length of the transect, or decreasing the distance between stations. Surveying a longer section of stream increases the distance from the point where stream condition was assessed. Decreasing the distance between points, increases the risk of double-counting individuals. While 250 m ensures independence of each point, previous studies in riparian vegetation found it was possible to reliably track birds already detected to avoid double counting (Dobkin and Rich 1998, Bryce et al. 2002).

In 2004, we will add 2 point count stations to each site, and reduce the distance between stations to 150 m, for a total of 5 survey stations along a 600 m transect. Counts will be reduced to 5 minutes in length and only detections within a fixed 50-m radius will be recorded to reduce repeat counting.

Area Searches

During area searches, we systematically searched the entire wetland area at a steady pace from the first to last point count station, for a total distance of 500 m (complete procedures in QAPP report). We recorded the total time spent searching in order to set a fixed time for 2004 surveys. We spent an average 29.7 (±6.4 SD) minutes searching willow-dominated riverine wetlands, and 19 (±4.16 SD) minutes searching herbaceous-dominated wetlands.

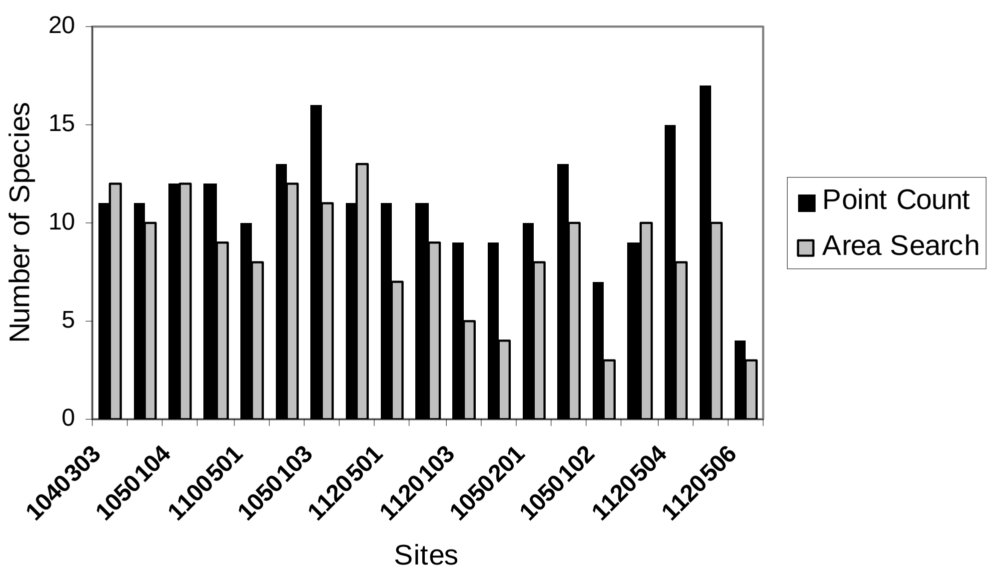
To increase the probability of detecting species, we will set search times at 45 minutes for willow-dominated sites and 30 minutes for herbaceous sites.

Area Search vs. Point Count Surveys

Significantly more species were detected during point count surveys than area searches (0.01 p-value, paired t-test; Fig. 1). At each site, however, species were found during area searches (particularly rare or secretive species) that were not detected in the point count surveys. Up to 4 additional species (x=1.53 ±1.33 SD) were detected by using both survey methods. In addition, across all surveys several riparian-associated species were only detected during area searches, including the lazuli bunting, belted kingfisher, and spotted sandpiper (Table A.1, A.2).

*Therefore, we will continue conducting both surveys during the 2004 season***.** Because keeping track of individual bird movements during area searches is difficult, abundance data from this method cannot be considered reliable. Therefore, only point count data will be used in abundance indices.

Figure C.1. Comparison of number of species detections at each site during point count and area search surveys at Red Rocks study area

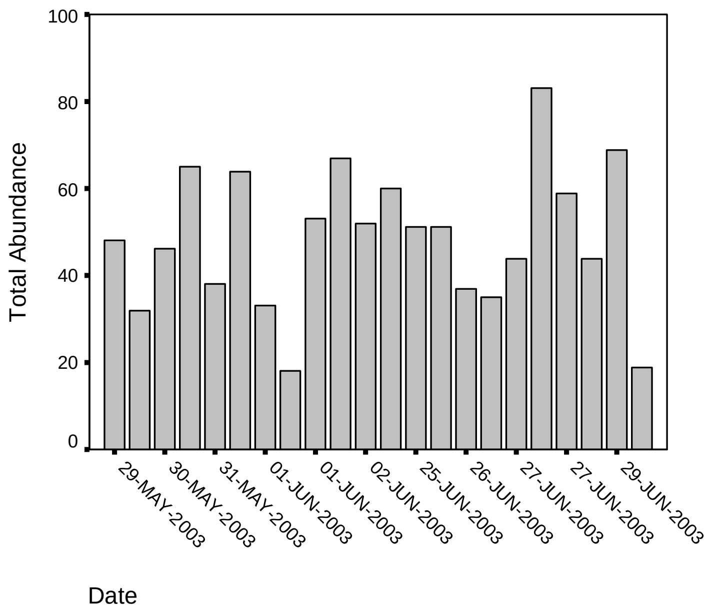


Repeat Surveys

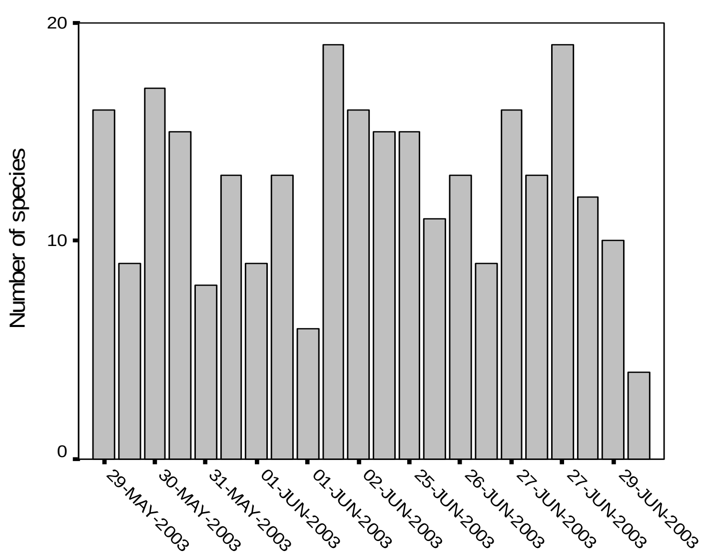
We assessed the need for conducting more than one survey at each site during the breeding season by examining the data for trends across the breeding season, and conducting a second survey at a sample of sites. There were no visible trends in total abundance or numbers of species at sites through the breeding season (Fig. C.2).

Figure C.2. Bar graph showing a)total abundance, and b) the number of species detected at each site by date of survey.

a)

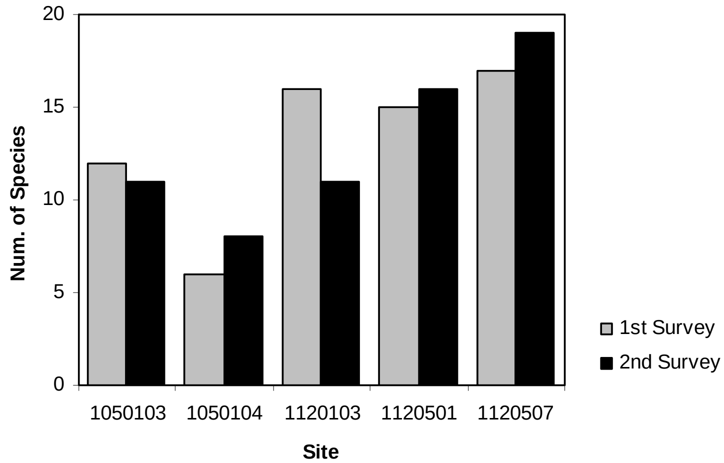


b)



We conducted two surveys at 5 of the sites— in late May and approximately a month later in late June. When point count and area search data were combined, there were no trends in the total number of species detected between the first and second survey (Fig. C.3).

Figure C.3. Total number of species detected during first and second surveys of sites



An average 72.6% (±9.7% SD) of the total species found were detected during a single survey. However, only 45% (±11.7% SD) of species were detected during both surveys, meaning there were a number of species that were unique to a single survey (Table C.2). More rare and secretive species were less likely to be detected during both survey dates, however graphical examination of individual species abundance provided no evidence that specific species were more or less likely to be detected earlier or later in the season.

Based on this data, in 2004 we will survey each site 2 times during the breeding season to maximize detection of species at each site.

Table C.2. Number of species detected at sites surveyed twice during 2003.

	Num. Species Detected in Surveys		
Site	1st only	2nd only	Both
1050103	4	3	8
1050104	1	3	5
1120103	10	5	6
1120501	4	5	11
1120507	8	10	9

Variability across Sites

At sites surveyed in 2003, the total number of bird species detected ranged from 3 to17 and abundance ranged from 14 to 45 (see Fig. C.2). Since the degree of human disturbance at sites surveyed in 2003 has not yet been determined, we cannot explore the data for relationships between wetland condition and bird community. However, the high degree of variation in bird species abundance and presence shows that there are detectable differences in the bird communities across sites, which may be related to differences in human disturbance levels.